Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

AMS Tracker Thermal Control Subsystem

TTCB and condenser integration welding into TTCS-loops

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Document change log

Change Ref.	*Section(s)*	*Issue 1.0*
-	All	Initial issue
Change Ref.	*Section(s)*	*Issue 2.0*
	Section 3.4	Type update
	Section 4.3	Weld samples update
	Section 7.2	Weld equipment additions
	Appendix M	Added Weld head specs
Change Ref.	*Section(s)*	*Issue 3.0*
	Appendix E	CoC Cres 347 added
	Section 4	Magnetic particle inspection deleted (not valid for stainless to stainlees welds) Update Table 4-3
Change Ref.	*Section(s)*	*Issue 4.0*
	Sections 8 to 10	All purge set-ups added

Contents

(86 pages in total)

1 Scope of the document

The procedure in this document describes the weld procedure for

- Welding the additional hydraulic connectors to the TTCS-scondary box and transport tubing needed to attach the mini-TTCS during beam testing.
- Welding the TTCB on-site in the AMS02 Clean room in CERN to the TTCS transport tubes.
- Welding the condensers on-site to the TTCS transport tubes
- Welding the hydraulic end connectors to the TTCB-boxes used for pinching and closing the system.

This document does NOT concern welding the hydraulic connectors connected to the evaporator. These welds are described in RD-2.

It contains the following steps:

- Weld qualification
  - Identification of optimum weld parameters
    (copy of the weld parameters from previous connector and tube welds)
  - Weld qualification
- Weld re-qualification (if necessary)
- Flight Weld steps
  - Pre-weld tubing check of TTCS connections
  - Pre-welds
  - Flight welding
  - Post-weld

The objective is to verify the hydraulic connector welds will fulfil the NASA weld requirements and meanwhile provide the safety verification documentation.

2 References documents

	Title	Number	Date
RD-1	TTCS Requirements Verification Matrix FM H/W	AMSTR-NLR-PL-02 Issue 1.0	April 2007
RD-2	REQUIREMENTS FOR THE MANUFACTURING AND SPACE QUALIFICATION OF ALL THE PRESSURIZED WELD JOINTS IN THE AMS TTCS EVAPORATOR	ASR-S-001 Rev B	Sept 2003

3 Identification of welds

3.1 Weld locations of additional hydraulic couplings

In the TTCS loop the new hydraulic connectors are present at the following locations:

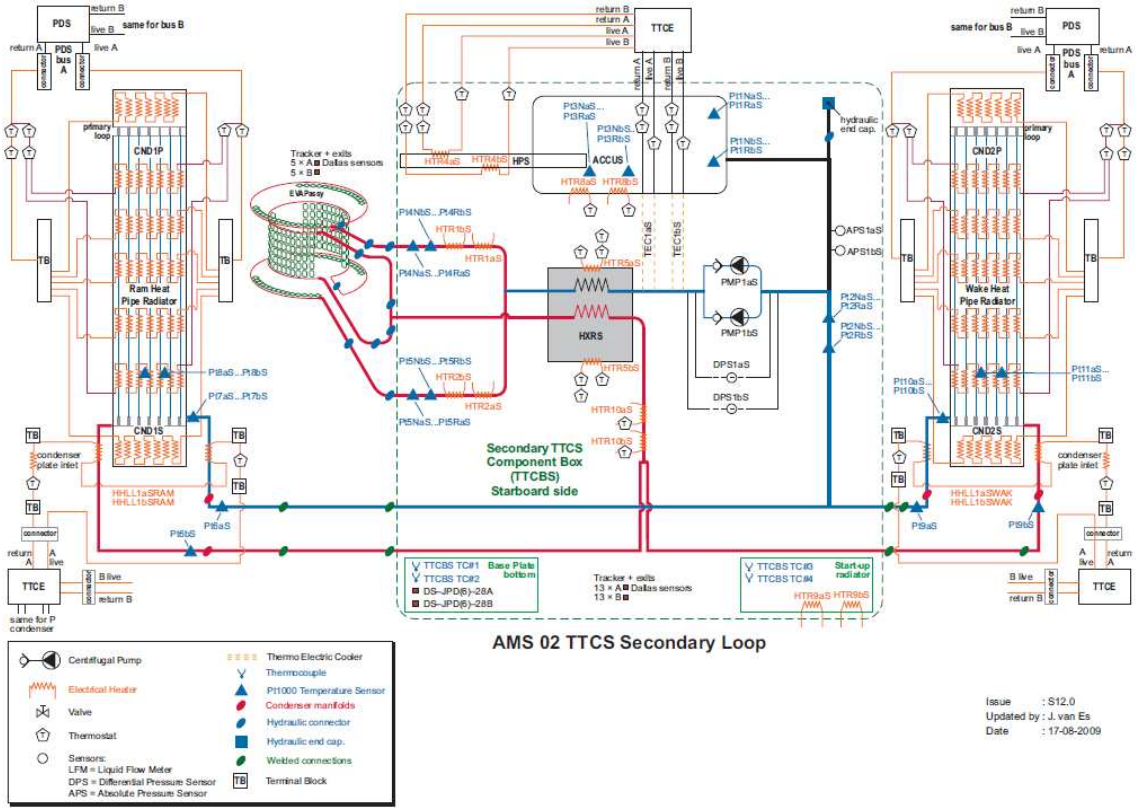
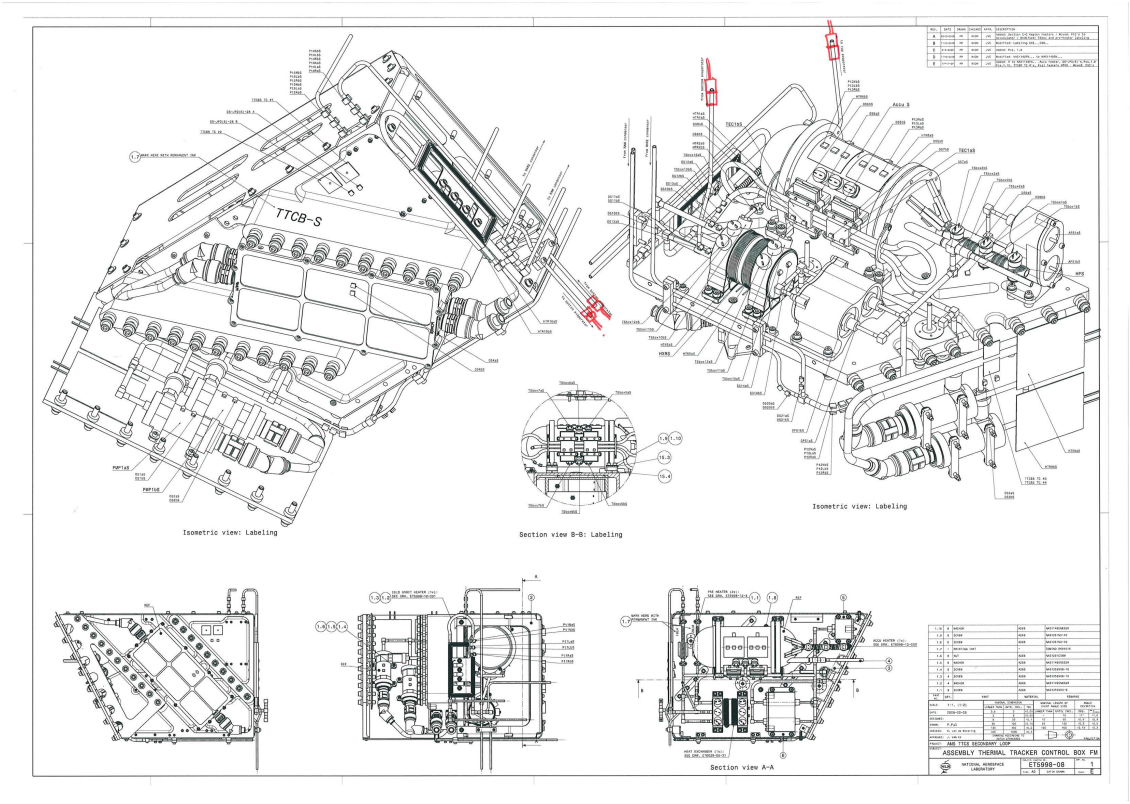


Figure 3-1: TTCS loop Schematic Secondary Loop

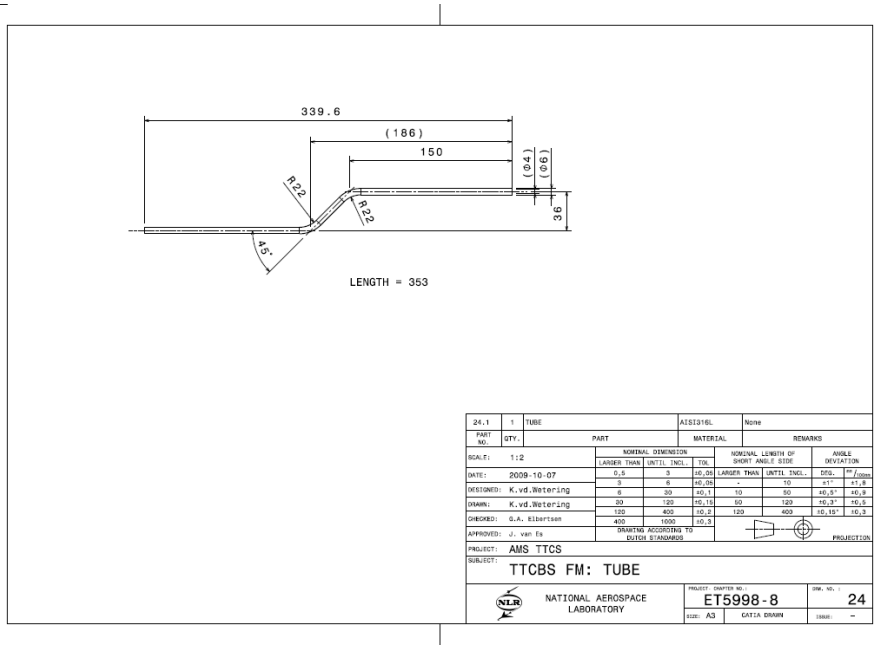
The secondary loop contains:

- 4 additional hydraulic connectors for the connection to the mini-TTCS
- 1 hydraulic connector for re-filling
- 1 hydraulic end cap

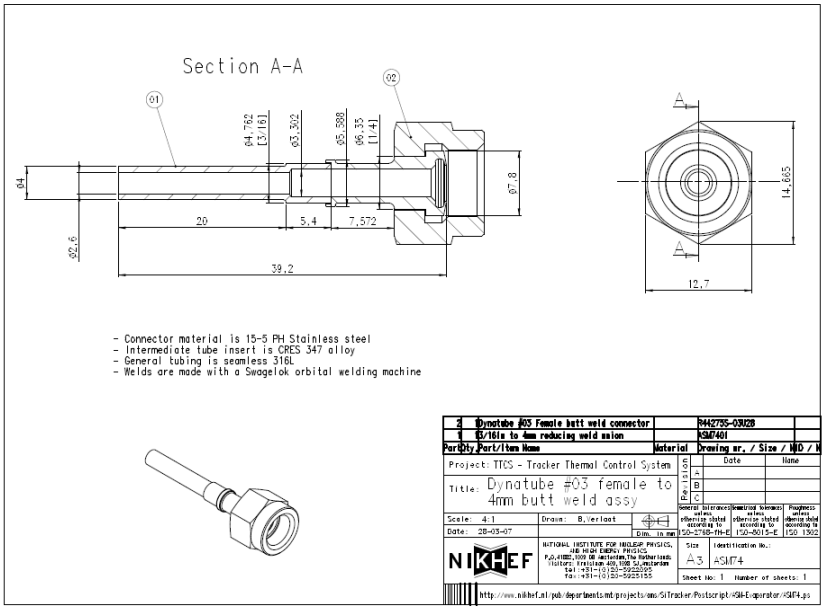
The location of the hydraulic connectors is shown in below assembly drawing:



Figuur 3-2: TTCB-S connector locations (to be updated soon)

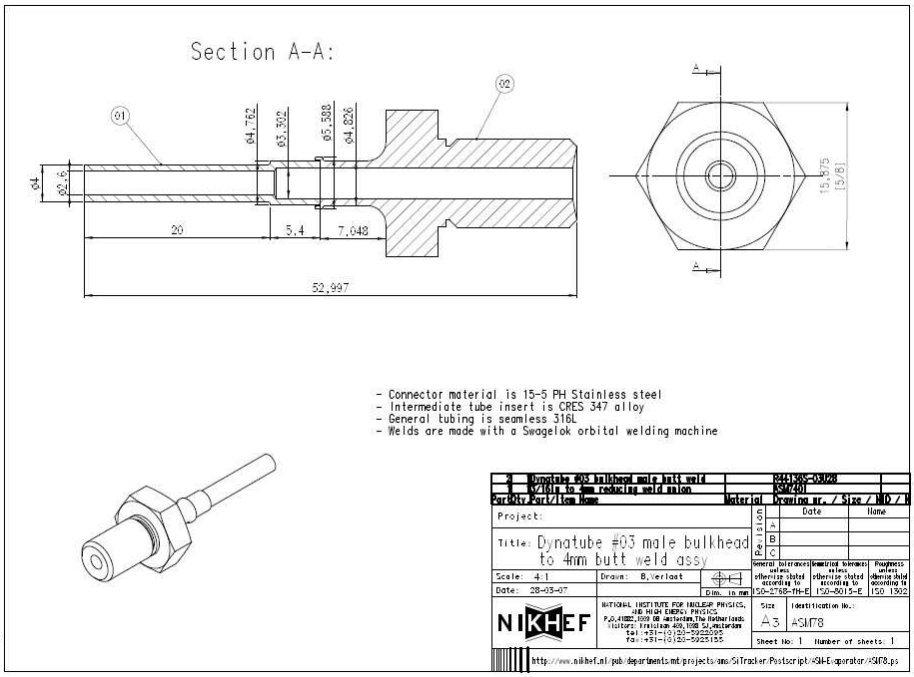


Figuur 3-3: TTCB-Secondary inlet tube drawing



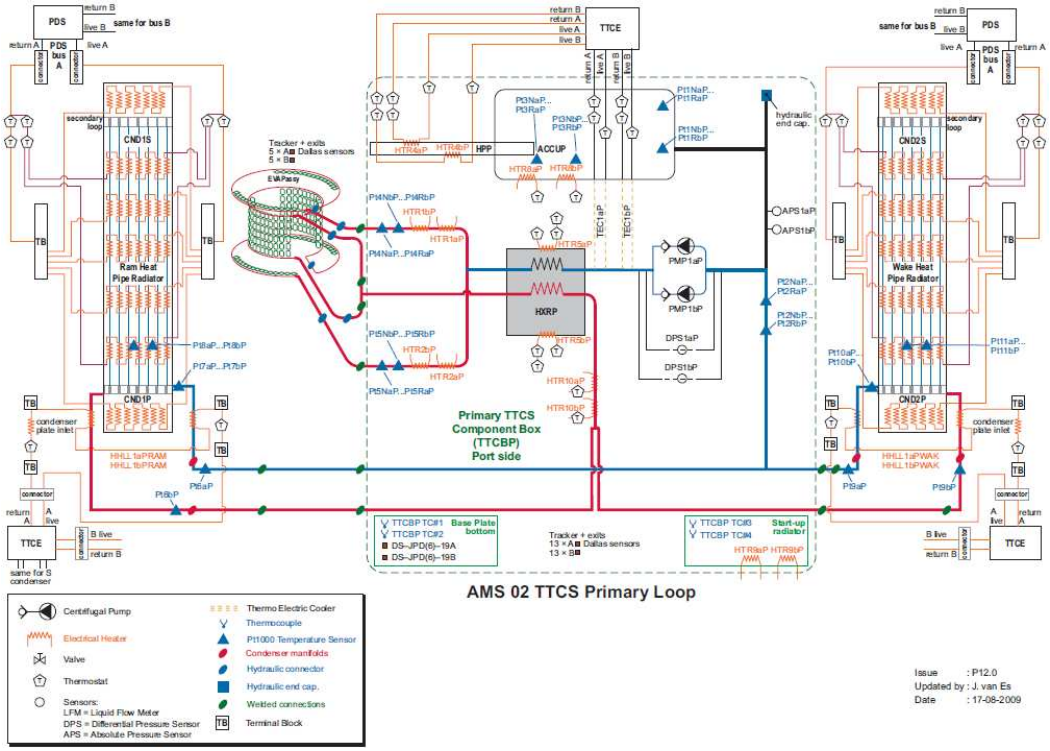
Figuur 3-4: Parker Hydraulic connector R44275S-03U28 with intermediate tube

The R44275S-03U28 Parker hydraulic connector (Material: PEP 15-5 PH) is connected to the TTCS transport tubes (316L) by a small tube segment with an intermediate material (CRES 347). The same construction is used for the mating coupling R44276S-03U28 as shown in Figuur 3-5.



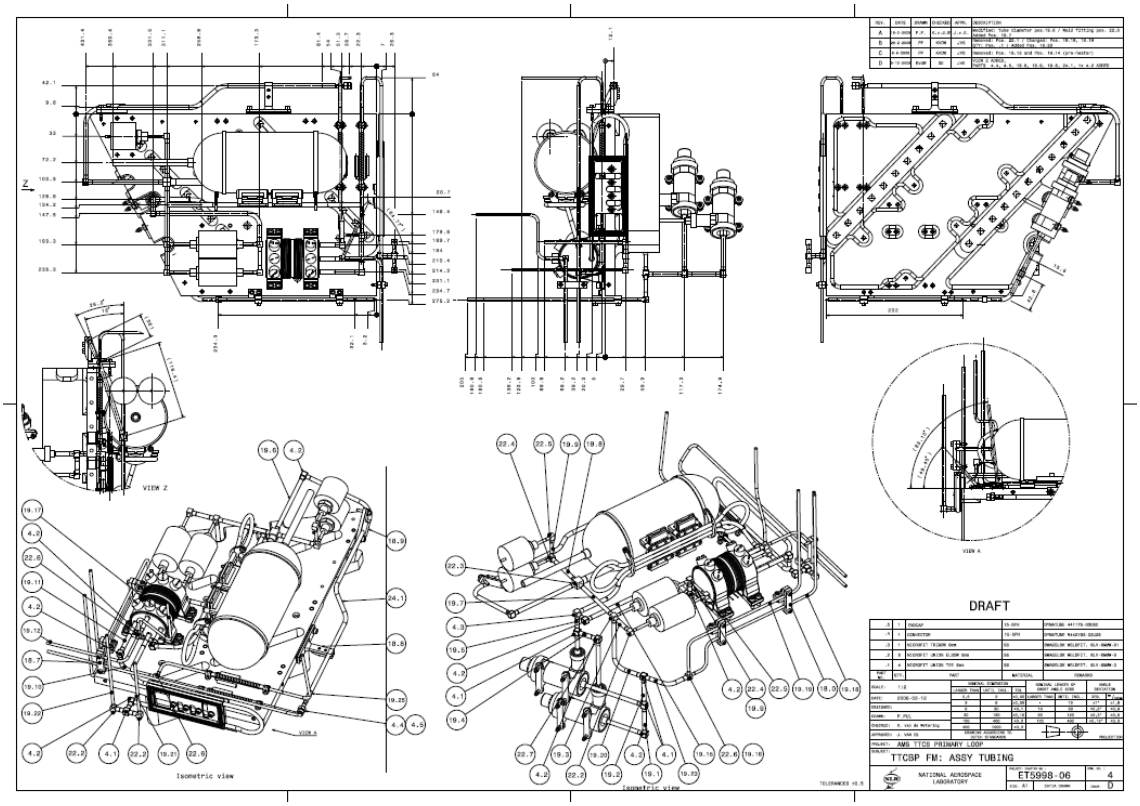
Figuur 3-5: Parker Hydraulic connector R44276S-03U28 with intermediate tube

For the end caps used at the fill ports also R44276S-03U28 couplings are used. However these are connected to 6 mm 316L tubes which leads to some a different intermediate tube (CRES 347). In Appendix A intermediate tubes are shown.

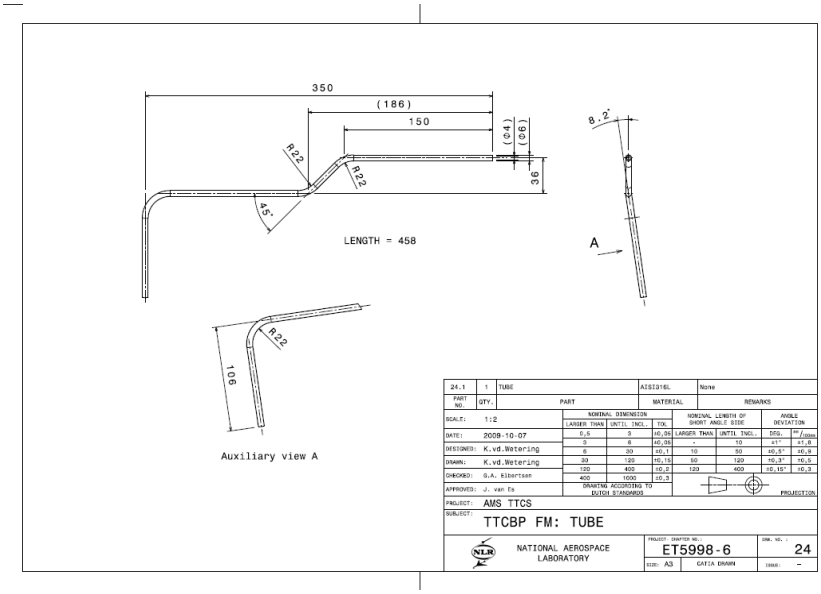


Figuur 3-6: TTCS loop Schematic Primary Loop

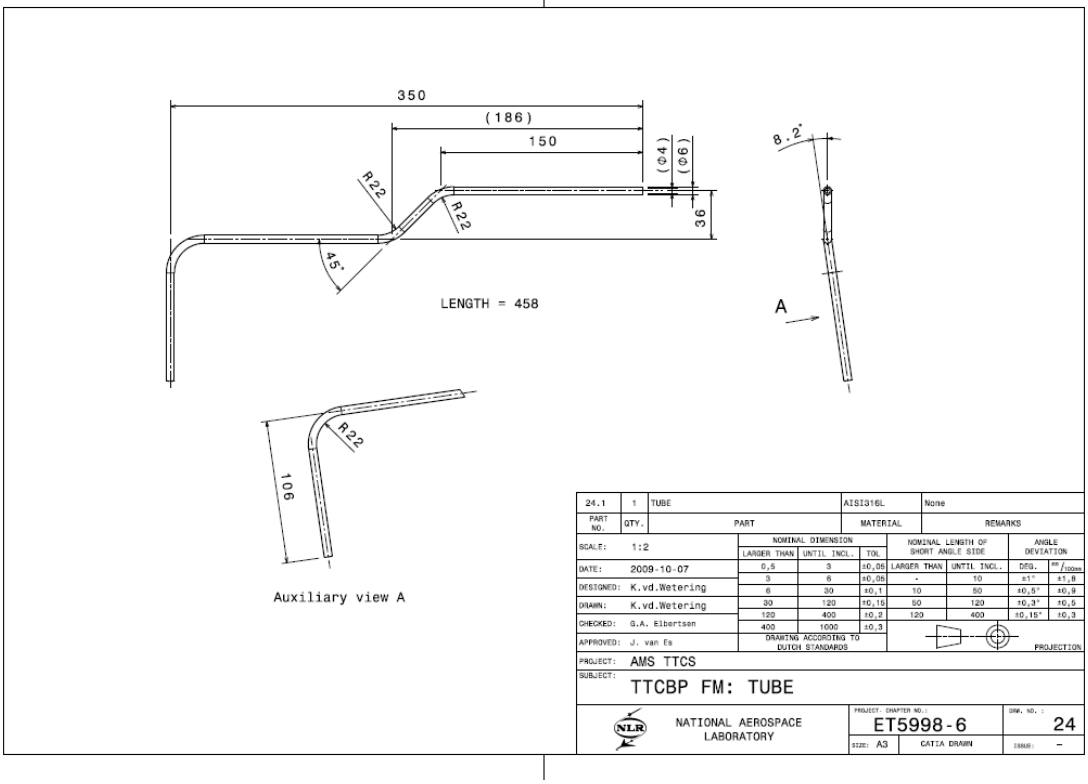
The primary loop only contains one hydraulic end cap. The inlet tubing is shown in Figuur 3-7 and Figuur 3-8.



Figuur 3-7: TTCB-Primary tube assembly drawing



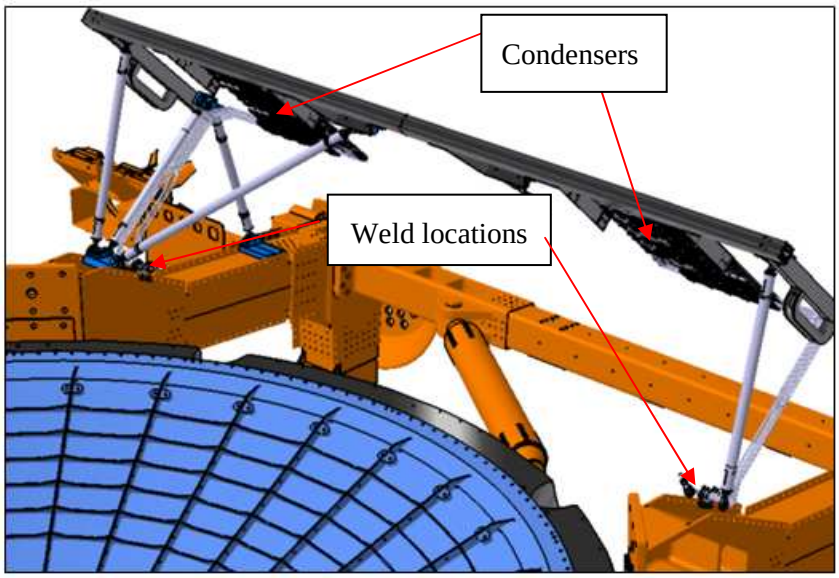
Figuur 3-8: Primary box TTCB inlet tube drawing



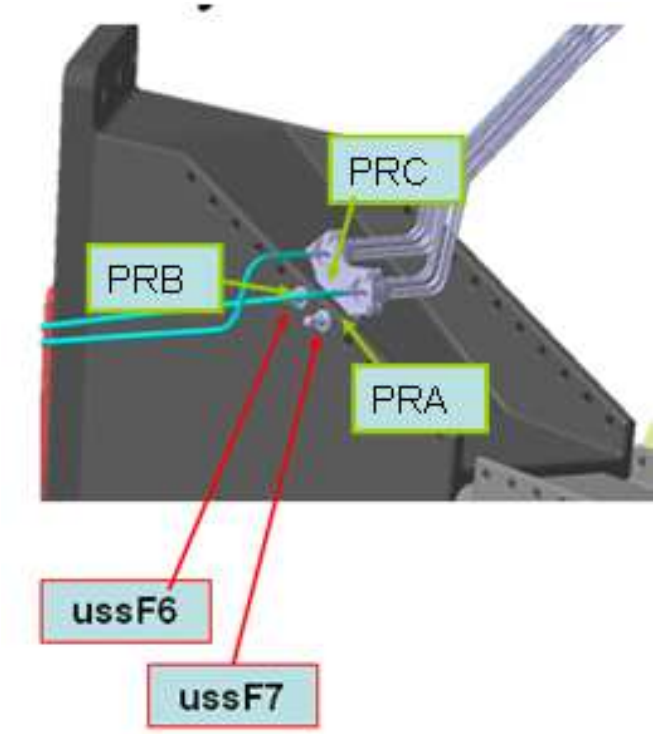
Figuur 3-9: TTCB-Primary fill tube drawing

3.2 Condenser inlet and outlet weld locations

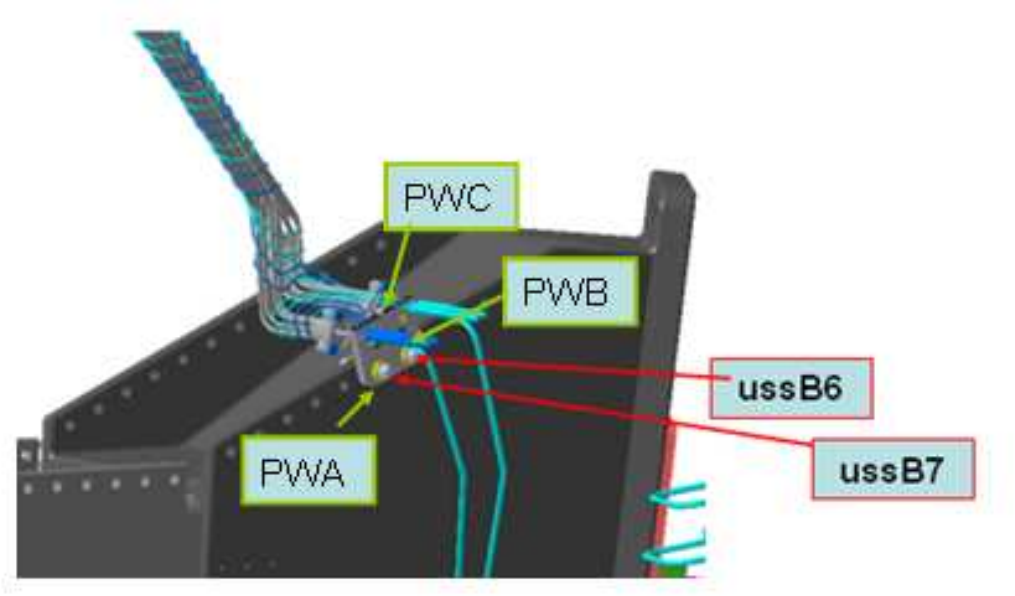
After condenser integration the transport tubes need to be welded to the condenser inlet and outlets. The TTCS has 4 condenser leadin a total of 8 online welds. Two condensers are located on RAM side and two on Wake side the mechanical lay-out is shown in below figures.The condenser welds are all of type V in Table 4-2.



Figuur 3-10: Condenser locations



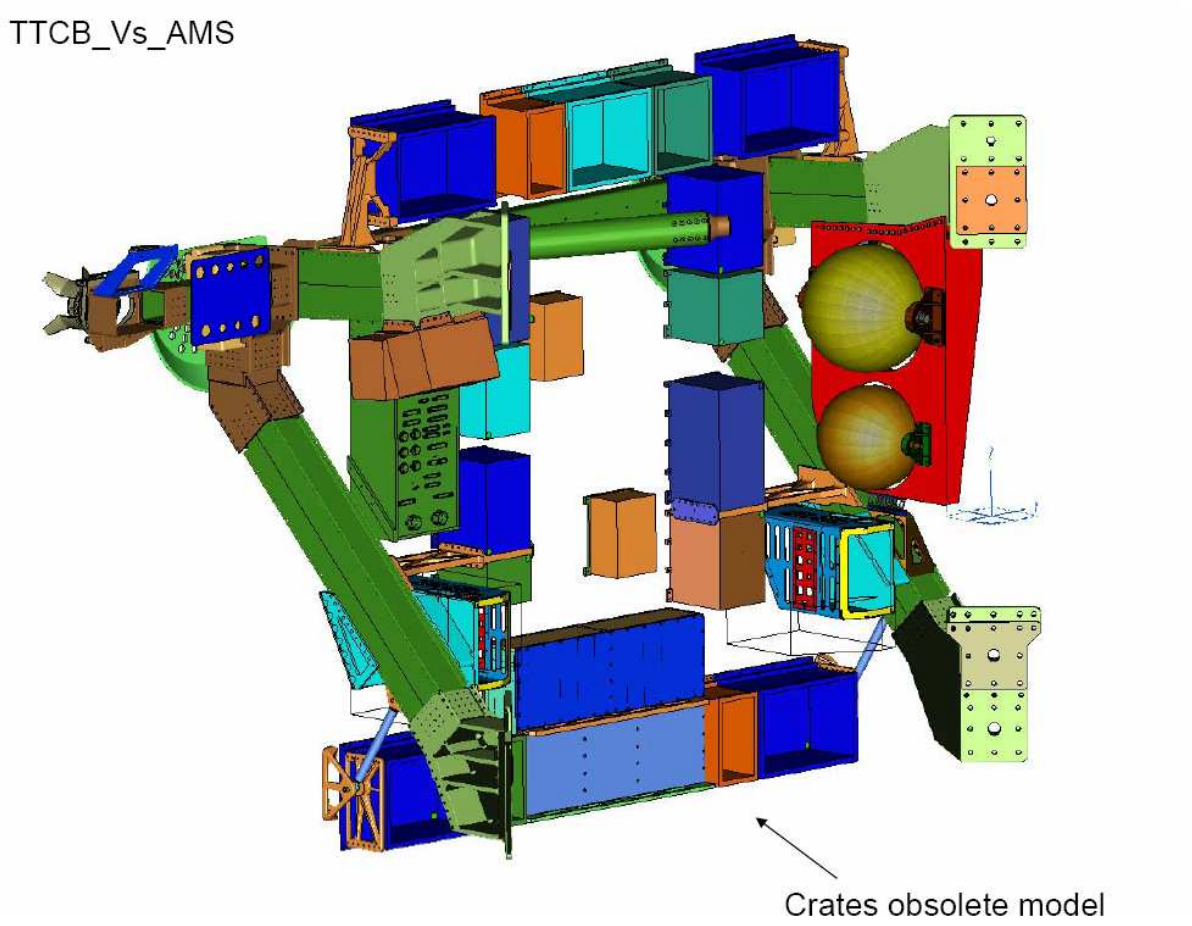
Figuur 3-11: Manifold inlet location details



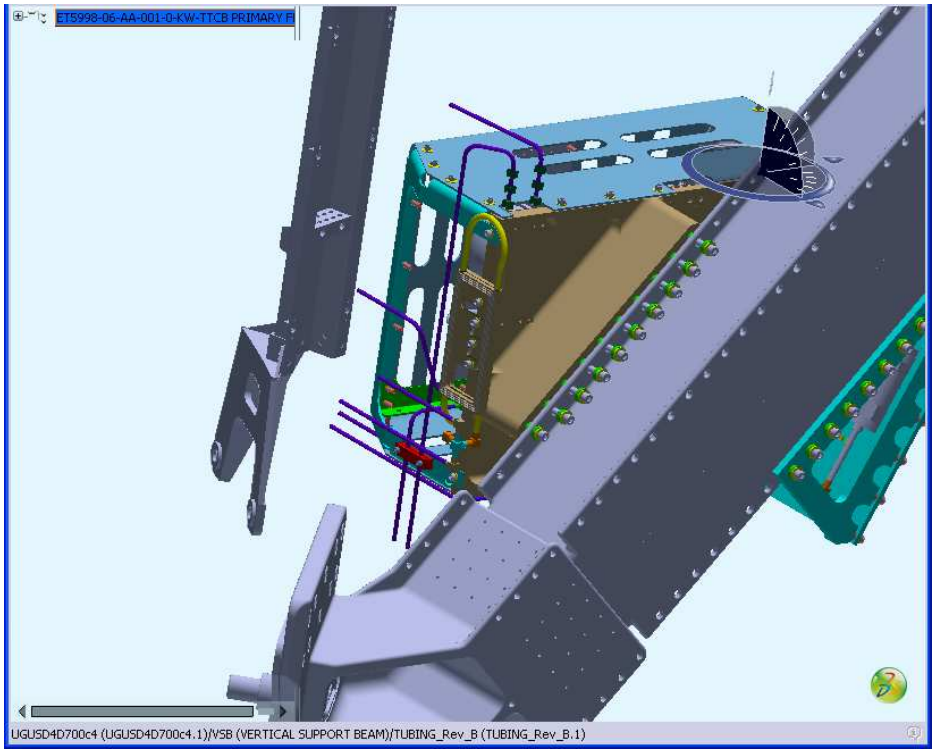
Figuur 3-12: Manifold inlet location details

3.3 TTCB connections weld locations

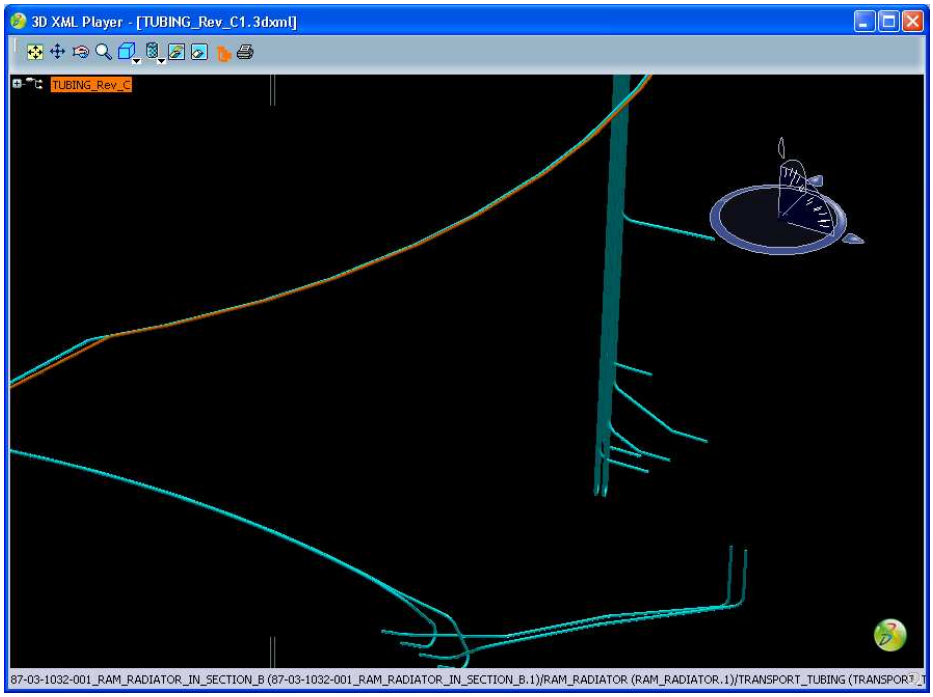
The TTCB's are located on the USS as shown in Figuur 3-16. The TTCB-P is located om Port side the TTCB-S on Starboard side.



Figuur 3-13: TTCB locations on AMS



Figuur 3-14: TTCB weld locations on AMS



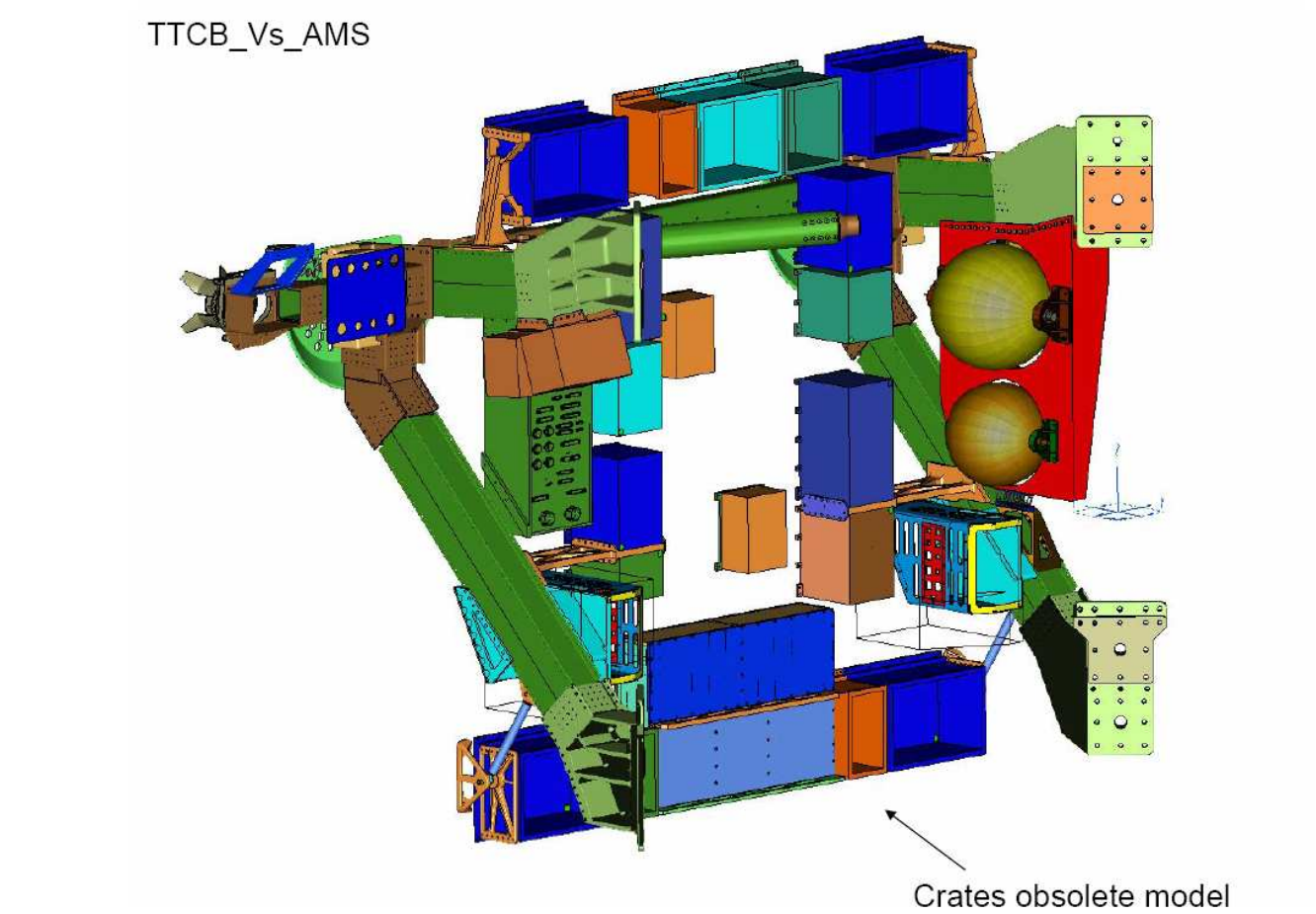
Figuur 3-15: TTCB tube routing AMS

3.3.1 TTCB-P welds

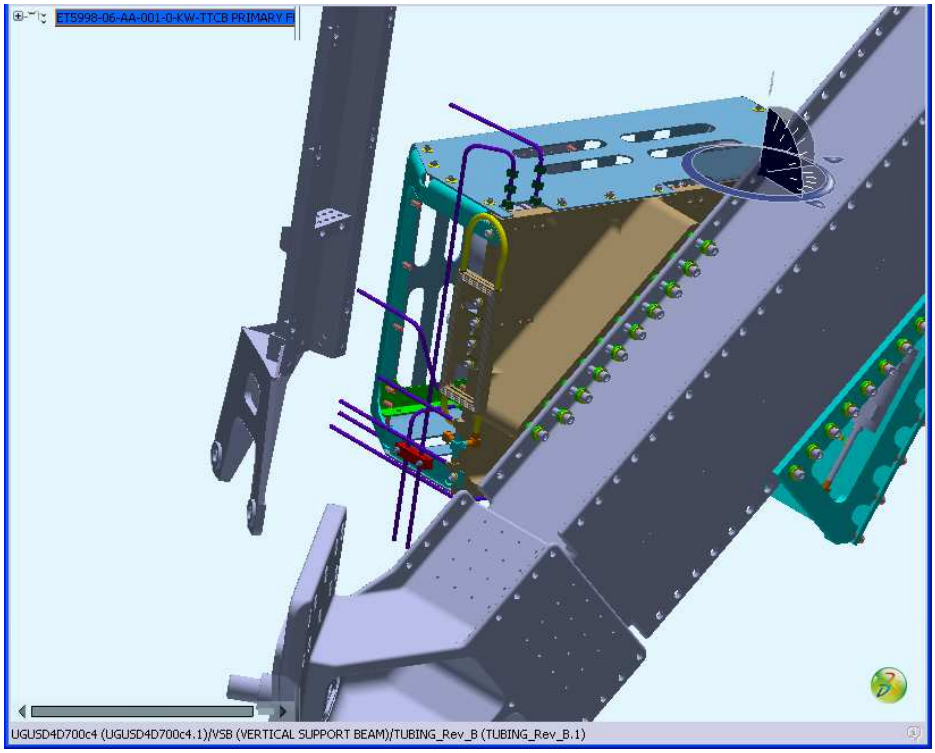
The TTCB-P will be completely welded into the TTCS-P tube system. This is a total of 8 welds. All welds are of the same type (Type IV in Table 4-2).

3.3.2 TTCB-S welds

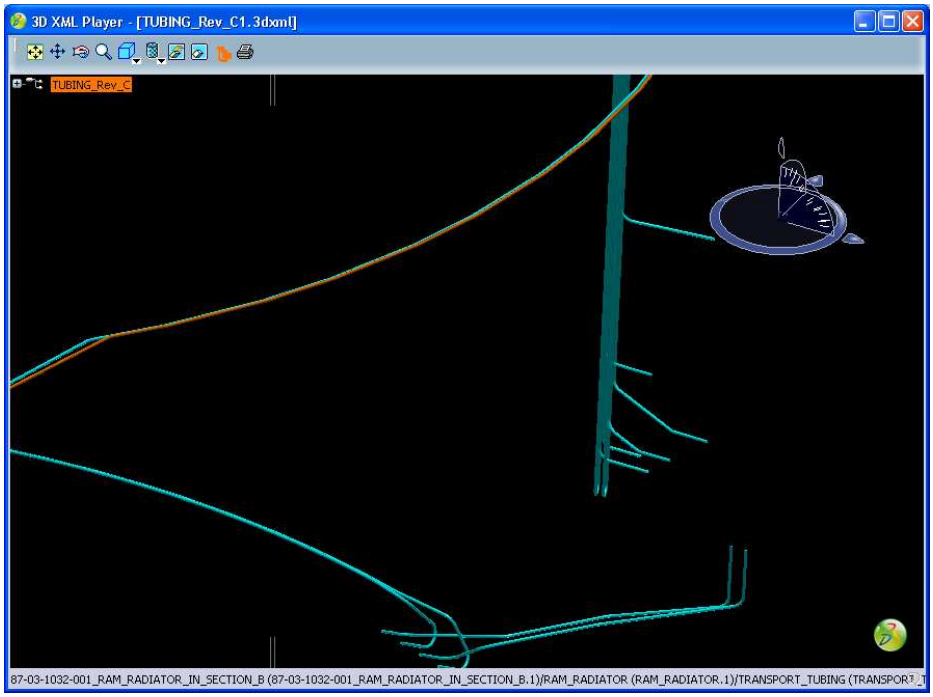
The connection to the TTCB evaporators is via connectors. The connectors on the box side (see Figuur 3-2) are welded off-line (type III in Table 4-2). The connectors on the transport tube side are welded on-line (Type IV in Table 4-2).
The TTCB-S has 4 TTCB condenser inlet and outlet connections will also be welded (Type IV in Table 4-2) online.



Figuur 3-16: TTCB locations on AMS



Figuur 3-17: TTCB weld locations on AMS



Figuur 3-18: TTCB tube routing AMS

3.4 Weld types identification

The welding of the hydraulic connectors to the transport tubes includes the following types of welds:

5.6 mm trumpet weld (all hydraulic connectors)

- Hydraulic connectors (R44276S-03U28 and R44275S-03U28) to intermediate CRES 347 tube sections

4 mm welds (mini-TTCS couplings)

- 4 mm standard tube stainless steel 316 L to 4 mm CRES 347 intermediate tube section
- 4 mm standard tube to 4 mm standard tube (both Microgroup batch)
  Connection to TTCS transport tubes
- 4 mm standard tube 316L (NIKHEF batch) to 4 mm standard tube 316L (Microgroup batch)
  Connection to TTCB's
- 4 mm standard tube 316L (Microgroup batch) to 4 mm 316L condenser manifolds
  Connection to condensers

6 mm welds (end coupling)

- 6 mm standard tube stainless steel 316 L to 6 mm CRES 347 intermediate tube section
- 6 mm standard tube 316 L to Swagelok weld coupling
- 6 mm standard tube 316 L to standard tube 316L

For each combination of materials a weld qualification is needed. The welds from different material batches are considered to be a different material and require additional qualification.

3.5 Class identification

All welds are classified as class B according to NASA document PRC0010. TTCS is a pressurised system and therefore class B requirements and methods for pressurised components are applicable.

4 Weld qualification

A weld qualification consists of the following steps:

- Identification of optimum weld parameters
- Weld qualification

The weld qualification is performed on a total of 9 weld samples.

Weld settings	Number of welds	Examination
Limit high heat input settings	3	1 cut sample (see Figure 4-1)
		2 normal samples
Limit low heat input settings	3	1 cut sample (see Figure 4-1)
		2 normal samples
Nominal heat input settings	3	1 burst sample
		2 normal samples
Total	**9**	

Table 4-1: Qualification samples quantity overview

All samples shall be send to NASA where they will be subjected to:

- Visually inspection to the Class B acceptance criterias in Appendix G.
- Liquid penetrant inspection Type I (fluorescent penetrant), Level 3 or higher to the Class B acceptance criterias in Appendix G.

One sample of high heat and one of the low input input settings shall be cut as shown below as

Figure 4-1: Longitudinal cut sample examples

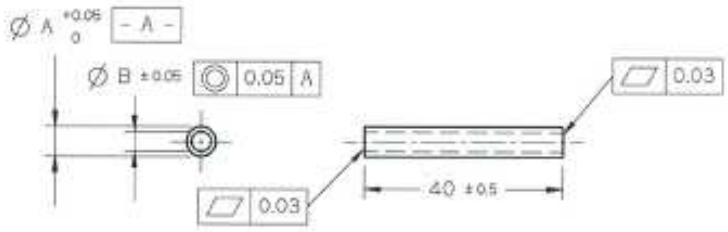
shown in Figure 4-1 to check the class B criteria in Appendix G focussed on through welding. One of the samples with nominal heat input settings shall be subjected to a burst test. The burst testing shall be done according to the test procedure requirements in Appendix J.

4.1 High and low heat input settings

The aim of the range of input settings shall be in the order of ±10%, but this is no hard requirement. The flight hardware welds shall be made with the nominal power setting. In this case the flight welds are qualified for power fluctuations in the welding apparatus between the low and high limits.

4.2 Standard Weld samples

The weld samples shall be cut in the same way as the flight hardware. A drawing of the weld samples is shown in Figure 4-2. Design drawings of all weld samples types are shown in Appendix H and I.



PART NO.	Dia. A	Dia. B
-101	6	4
-102	4	2.4

Figure 4-2: Weld sample example

4.3 Qualifications summary

In the following table the required samples are summarised.

DIAMETER	TYPE Orbital Welding		Picture	QUALIFICATION	RE-QUAL
5.6	Type I	Hydraulic connector material to CRES347 5.6 mm OD	N/A	9	3
4	Type II	CRES 347 to 316L 4mm OD (Microgroup batch)	N/A	9	3
4	Type III	316L (Microgroup batch) -316L (Microgroup batch)	N/A	9	3
4	Type IV	316L (NIKHEF batch) -316L (Microgroup batch)	N/A	9	3
4	Type V	316L 6mm (Microgroup batch) to 316L Condenser manifold	N/A	9	3
6	Type VI	CRES 347 to 316L 6mm OD	N/A	9	3
6	Type VII	316L 6 mm OD to swagelok weld coupling	N/A	9	3
6	Type VIII	316L to 316L 6mm OD standard	N/A	9	3

Table 4-2: Summary of qualification samples

The inventory of the sample parts is shown in Table 4-3.

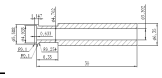
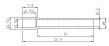
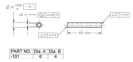
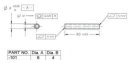
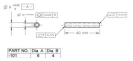
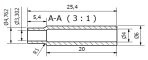
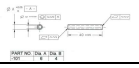
DIAMETER	SAMPLE TYPE		Picture	# PARTS REQUIRED		#STOCK	
5.6		Hydraulic connector material (15-5 PH) samples		23	(Q/F/P&P) (9/8/6)	26	
4		CRES 347 intermediate connectors 4 mm		32	(Q/F/P&P) (18/8/6)	50	
4		4mm OD tube (NIKHEF batch) 316L		15	(Q/F/P&P) (9/0/6)		>10 m
4		4mm OD tube (Microgroup batch) 316L		56	(Q/F/P&P) (36/8/12)		9 m
4		4mm OD machined tube 316L (condenser manifold batch)		15	(Q/F/P&P) (9/0/6)	30	
6		CRES 347 intermediate conector 6 mm		19	(Q/F/P&P) (9/4/6)	30	
6		6mm OD tube 316 L		39	(Q/F/P&P) (27/0/12)		6 m
6		6 mm OD 6LV-6MMW-9 swagelok weld coupling 316 L		17	(Q/F/P&P) (9/2/6)	30	

Table 4-3: Sample inventory

5 Welding procedure specification (WPS)

Process verification shall consist of visual inspection and/or (non)-destructive inspection, as described further in section 4 for weld qualification and section 6 for re-qualification. In addition, at the appropriate time during the fabrication activities, the following items shall be verified:

a. Verify that the welder is certified for the specific welding operation (prior to welding).
b. Fit-up in accordance with the engineering drawing (prior to welding for Class A Pressure Containing Components).
c. A WPS exists (prior to welding) see section 5.1.
d. Compliance with WPS for essential variable ranges (during welding).

5.1 Welding procedure specification (WPS)

The welding process shall be documented in a Welding procedure specification (WPS). The WPS shall be reviewed by NASA before the production of the actual flight and qualification H/W. An example WPS as will be used for TTCB welding is shown in Appendix K.

5.2 Welding Procedure Qualification Record (PQR)

Welding results (all qualification, re-qualification, post and pre-weld sampled) shall be documented in a Procedure Qualification Record (PQR). An example PQR as will be used during flight qualification and flight welding is given in Appendix K.

6 Weld re-qualification

Re-qualification of welds will be performed in the following cases:

- The weld system has been placed on a different external power source except when the power supply has a means for internal power regulation,
- Major maintenance has been performed on the weld system. Major maintenance includes replacement of the power supply, major repair of the power supply requiring entrance into the controller or transformer cabinet, replacement of the weld head, or replacement or change in length of any of the interconnecting cables.

A re-qualification exists of the following steps:

- Weld re-qualification

Weld settings	Number of welds	Examination
Limit high heat input settings	1	Visual Inspection Volumetric NDE
Limit low heat input settings	1	Visual Inspection Volumetric NDE
Nominal heat input settings	1	Visual Inspection Volumetric NDE
Total	**3**	

Table 6-1: Qualification samples quantity overview

Re-qualification requires only 3 samples with settings and sequence as shown above. The samples are subjected to visual inspection and volumetric NDE. The re-qualification results will be send electronically to NASA and to NLR for approval.

If the requalification activities result in any welding parameter(s) deviations that exceed the range specified in Table V of PRC0010 or AWS B2.1 as applicable, for that parameter, then the level of testing in section 4 is required. Table V is copied below.

Table V - Essential Welding Variables

Variable #	Variable / Weld Type	Range Allowed
1	Power Source Model #	None
2	Weld Head Model #	None
3	Joint Configuration	None
4	Groove Angle	+/- 5^{o}
5	Nominal Tube Dia.	None
6	Nominal Wall Thickness	None
7	Material Type(s)	None
8	Electrode Start Position	+/- 60^{o}
9	Preweld Cleaning Steps	None
10	Allowable Joint Gap	None
11	Tool or Shop Aid Identification	None
12	Preweld Purge Time	(1)
13	Postweld Purge Time	(1)
14	Tube ID Prepurge Flow Rate or Pressure	None
15	Weld Head Prepurge Flow Rate	+/- 15%
16	Plasma Gas Flow Rate	+/- 10%
17	Gas Composition/Spec.	None
18	Electrode Travel Speed & Machine Setting	None
19	Arc Travel Start Delay	None
20	Total Weld Current On Time	None
21	Weld Time @ Level or Circumference Interval	None
22	Current Pulse Width (%)	None
23	Current Pulse Rate	None
24	Filler Material / Spec.	None
25	Filler Wire Feed Speed	+/- 50%
26	Consumable Insert Type and Specification	None
27	Tubular Sleeve Spec.	None
28	Background Welding Current	None
29	Pulse Welding Current	None
30	Electrode Type	None
31	Electrode Diameter	None
32	Electrode Tip Geometry	None
33	GTAW Electrode to Work Gap (nom. setting)	+/- 10%
34	PAW Electrode Position Setting (nom. setting)	+/- 10%
35	PAW Orifice Size	None
36	Minimum Preheat Temp.	None
37	Maximum Interpass Temp.	None
38	PWHT Procedure/Spec.	None

Tabel 6-2: Essential welding variables

7 Flight Welding

For welding of the hydraulic connectors tube welding with flow-through shielding gas is used. The detailed integration weld sequence is described in section XX.

7.1 Tube welding preparations

7.1.1 Cleaning and clean working

The welding and welding preparation of the tubing and components will be performed in a class 100,000 or better clean room environment. The flight tubes and flight weld samples are clean inside. Handling is focussed in avoiding contamination to get inside and keep the tubes clean.
For cleaning on the outside Iso-Propyl-Alcohol (IPA) will be used as it leaves no residue on the tubes. Details of the cleaning are described in the TTCS Box bending procedure AMSTR-AIDC-PR-020.

7.1.2 Tube cutting

Tube cutting will be done according to the tube cutting procedure AMSTR-SYSU-PR-008. Cutting will be done while filtered clean gas is flown through the tube. Special to the tube cutting is to take into account (add) the tube shrinkage during welding. Before cutting need to add the welding shrink dimension. This dimension was tested.

7.1.3 Pre-weld and post-weld samples

In order to assure the weld quality during the complete TTCB integration process each day:

- two pre-weld samples (for each weld type performed that day)
- one post-weld samples (for each weld type performed that day)

The pre- and post-welds are made according to the WPS and examined and documented in a PQR by NIKHEF. At the end of each day the filled procedures and PQR's are send to the NASA weld specialist and the TTCS project leader for review.

Pre-production anomalies

In case pre-production weld samples do not meet requirements and no assignable cause for the failure can be determined the welding activities will be stopped at once. The TTCS project leader at NLR, and the NASA weld specialist shall be contacted as soon as possible to discuss how to proceed.

In order to reduce the number of pre- and post-welds as much as possible the same weld types are planned on one day.

7.2 Weld equipment

Figuur 7-1: Swagelok welding system

The orbital welds will be made with a Swagelok/Cajon™ M100 orbital welding system. The system includes the following hardware:

· Welding head: Cajon™ CWS-5H-B
· Fixture block: Cajon™ CWS-5TFB
· Collets: Cajon™ CWS-5UCI-04mm

The on-line welding will be done with a micro weldhead series 4 as shown in Appendix M. Fixtures are available for 4 mm and 6 mm tubes

7.3 Standard tube orbital welding with flow-through shielding gas

The standard tube orbital weld method is used for most of the TTCB welds. The purge gas set-up is shown in Figure 7-2.

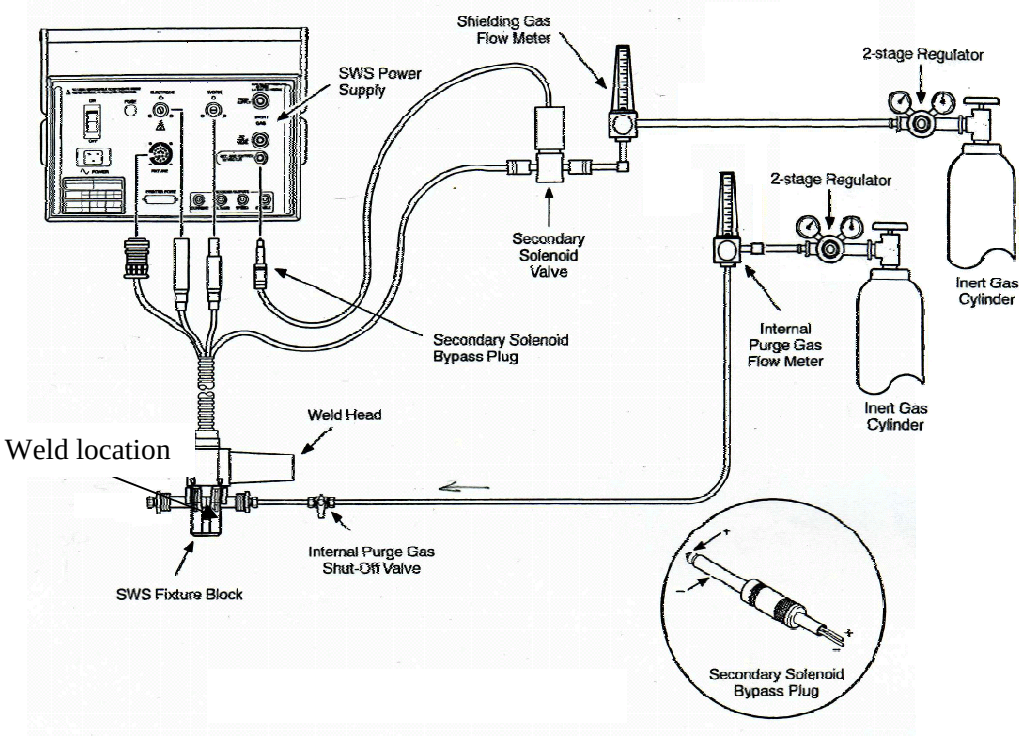
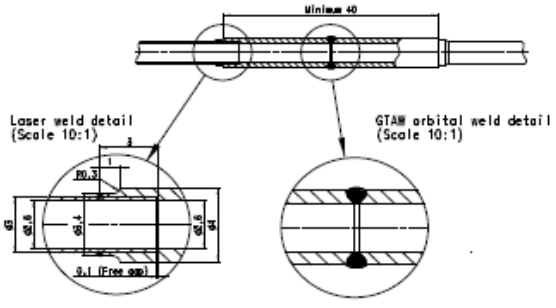


Figure 7-2: Purge gas set-up flow through

In Figuur 7-3 you find a typical weld sample.



Figuur 7-3: Drawing of a tube weld connection concept

7.3.1 Main steps for welding with flow-through shielding gas

The main steps are:

1. Perform pre-weld test samples according to the applicable WPS in Appendix L.
    a. Use fixture to fix tube in line
    b. Purge gas with DP gage before welding
    c. Perform welding
2. Document the weld parameters in PQR as in Appendix K.
3. NDE Examination of weld samples
    a. If samples fulfil requirements
        i. Document the weld sample examination results
        ii. Proceed with flight welding preparations
    b. If samples do not fulfil requirements
        i. Find out cause of anomaly and report to TTCS PM
        ii. If anomaly is well understood start with step 1 and continue
        iii. If anomaly is not understood stop welding and contact TTCS PM and NASA weld specialist at once to discuss how to proceed.
4. Flight weld preparations
    a. Document part numbers
    b. Check material traceability and certificates
5. Perform flight welding
    a. Use fixture to fix tube in line and/or components
    b. Take picture of weld set-up
    c. Purge gas with DP gage before welding
    d. Perform welding
6. Direct after last weld of the same weld type perform post-weld sample
    a. Use fixture to fix tube in line
    b. Purge gas with DP gage before welding
    c. Perform welding
7. NDE Examination of post-weld sample
    a. If sample fulfils requirements
        i. Document the weld sample examination results
        ii. Continue with other weld type(s)
    b. If sample does not fulfil requirements
        i. Report to TTCS PM and to NASA weld specialist

8 TTCB and hydraulic connector weld sequence

The overall sequence of welding is as follows:

1. Off-line Connector weldings to CRES 347 and 316L (NIKHEF batch 4mm) @NIKHEF (these are the mini TTCS connector welds for TTCB-S)
    a. Pre welds
    b. 8 welds CRES347 to 316L 4 mm
    c. 8 welds CRES347 to connector 5.6 mm
    d. Post welds
2. Off-line Connector weldings to CRES 347 and 316L (6mm Dockweiler) @NIKHEF (this are the pinch tube welds for TTCB-P and TTCB-S)
    a. Pre welds
    b. 6 welds CRES347 to 316L (Dockweiler) 6 mm (including 1 spare pinch tube)
    c. 6 welds CRES347 to connector 5.6 mm
    d. Post welds
3. Condenser welds on AMS02 online @CERN
    a. Pre welds
    b. 8 welds 316 L (manifolds) to 316 L (Microgroup batch)
    c. Post welds
4. TTCB's Fit check on AMS02 online
    a. Check hydraulic connector locations (tooling access etc)
    b. Check pinch locations
5. Off-line connectors welds to TTCB-S @CERN
    a. Pre welds
    b. 8 welds 316L (NIKHEF batch) to 316L (NIKHEF batch) 4 mm (to connect the connectors to TTCB-S)
6. Off-line connectors pinch inlet TTCB-S & TTCB-P @CERN
    a. Pre welds
    b. 2 welds Swagelok weld coupling to 316L (Dockweiler) 6 mm (with attached connector(s))
    c. 2 welds Swagelok couplings to 316L (Dockweiler) (inlet TTCB) 6 mm (TBC could also be online to better fit with the bracket)
    d. Post welds
7. On-line welds TTCB-P

a. Pre welds
b. 8 welds 316 L (NIKHEF batch) to 316 L (Microgroup batch)
c. Post welds

8. On-line welds TTCB-S
   a. Pre welds
   b. 4 welds 316 L (NIKHEF batch) to 316 L (Microgroup batch)
   c. Post welds

Green = @ NIKHEF
Yellow = off-line @ CERN
Red = on-line at AMS02 @ CERN

In the section 9 the purge set-up for the off-line and online connections to the TTCB's are shown. The TTCB fit checks are found in a separate ATS of on-line AMS02 activities.

9 Purge set-ups during off-line box welding

In below pictures the purge set-up are shown of:

- TTCB-S off-line welds 4 mm
- TTCB-S off-line welds 6 mm
- TTC-P off-line welds 6 mm
- Condensers welds online welds
- TTCB-P online welds 4 mm
- TTCB-S online welds 4 mm

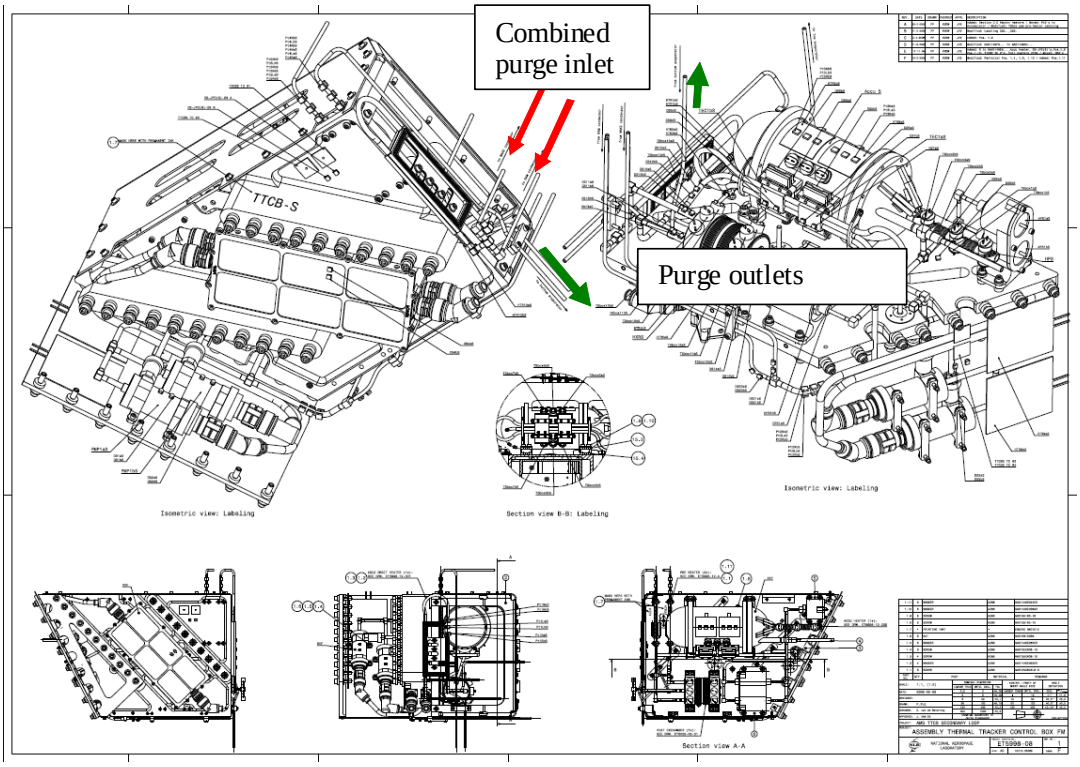
The following general rules are applied.

- All welds will be performed as flow-through type welds
- Downstream the weld no (major) hydraulic resistance (e.g. pump) should be present (This would influence the back pressure measurement and so a different weld situation would be present than during flight and qualification)

9.1 TTCS-S off-line weld connector assemblies to box tubing 4 mm

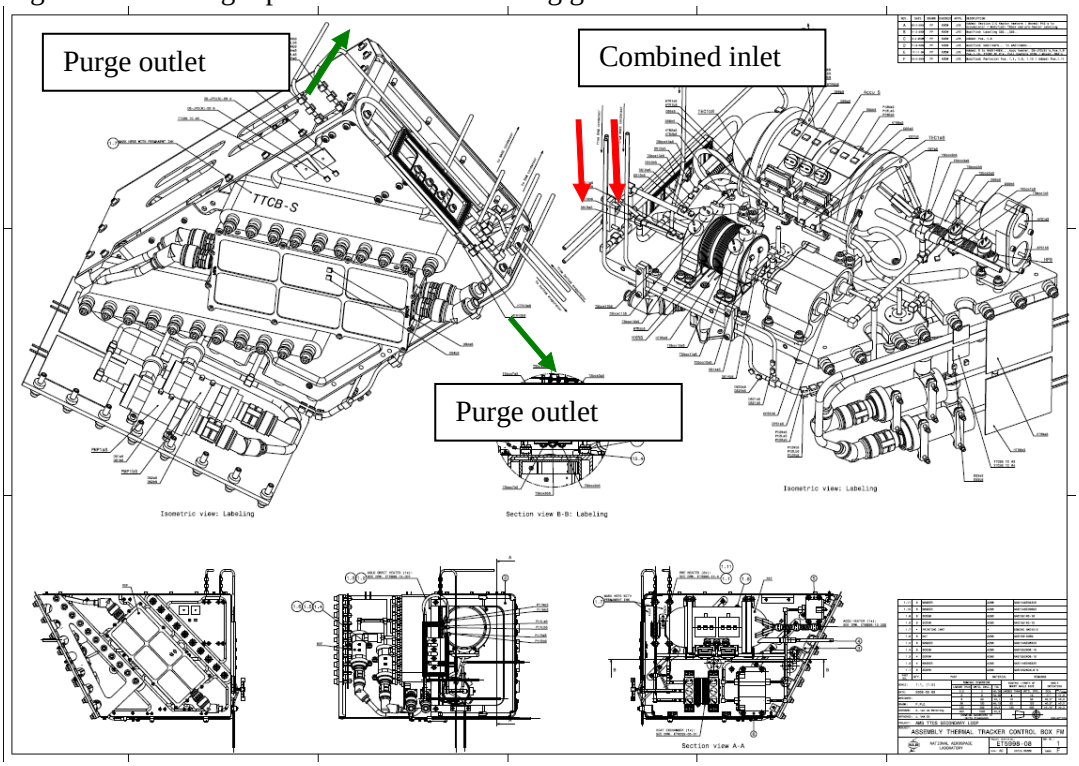
The following weld steps will be performed:

1. Cut and debur tubes according to AMSTR-NLR-PR-008 Issue 4 “Condenser and TTCB tube cutting Procedure”
2. Perform pre-weld samples before flight welding
3. Purge to fill HX two-phase side with shielding gas
   (use filters in the shielding gas purge line to avoid contamination)



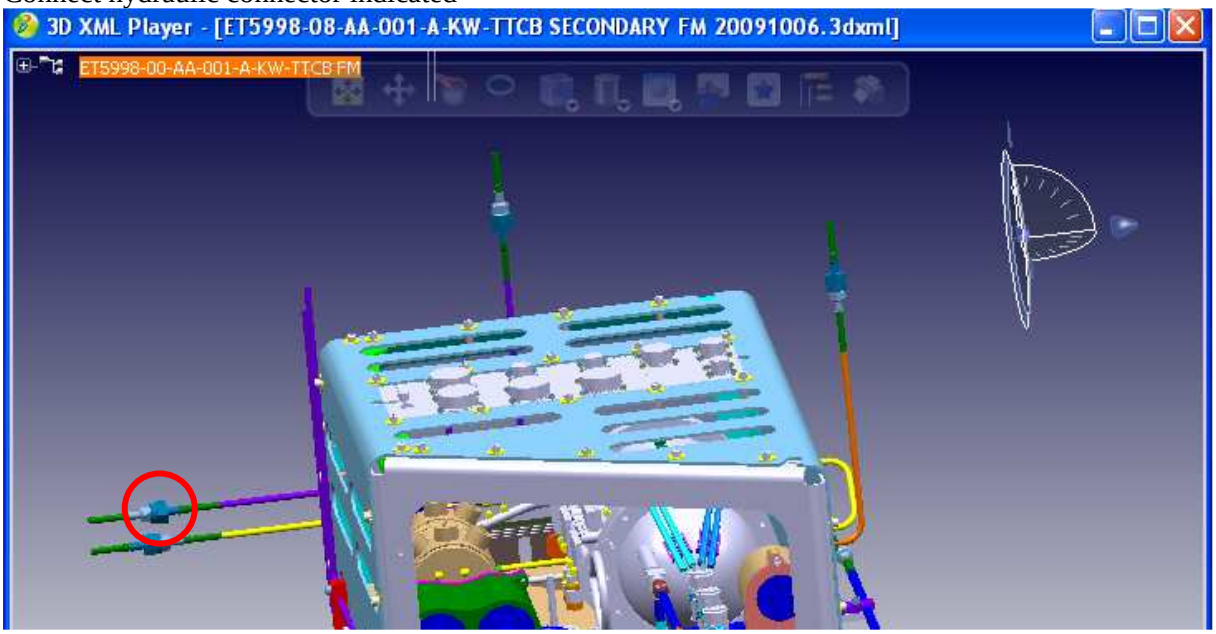
a. Close ends after purging with kapton tape

4. Purge to fill HX single-phase side with shielding gas

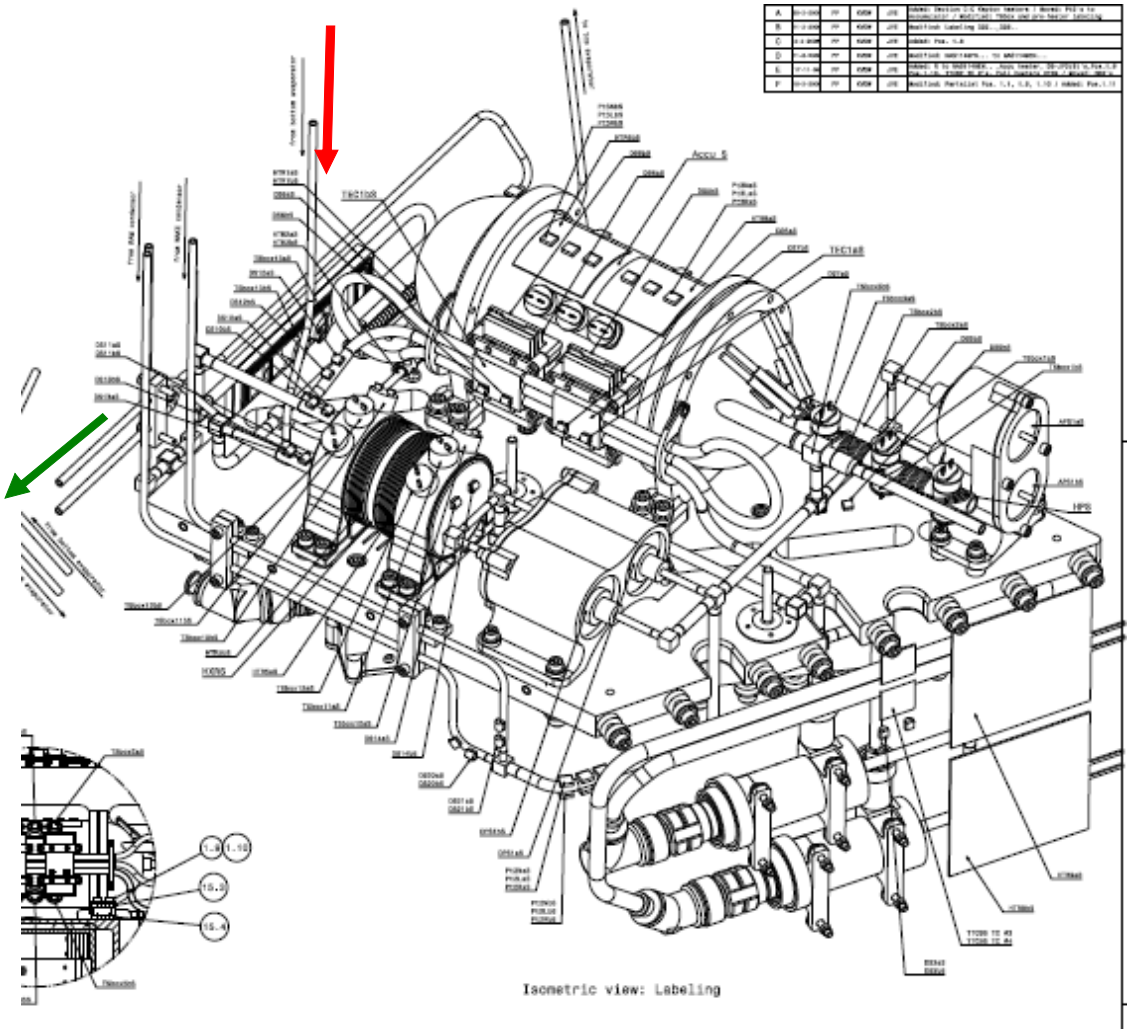


a. Close ends after shielding

5. Connect hydraulic connector indicated

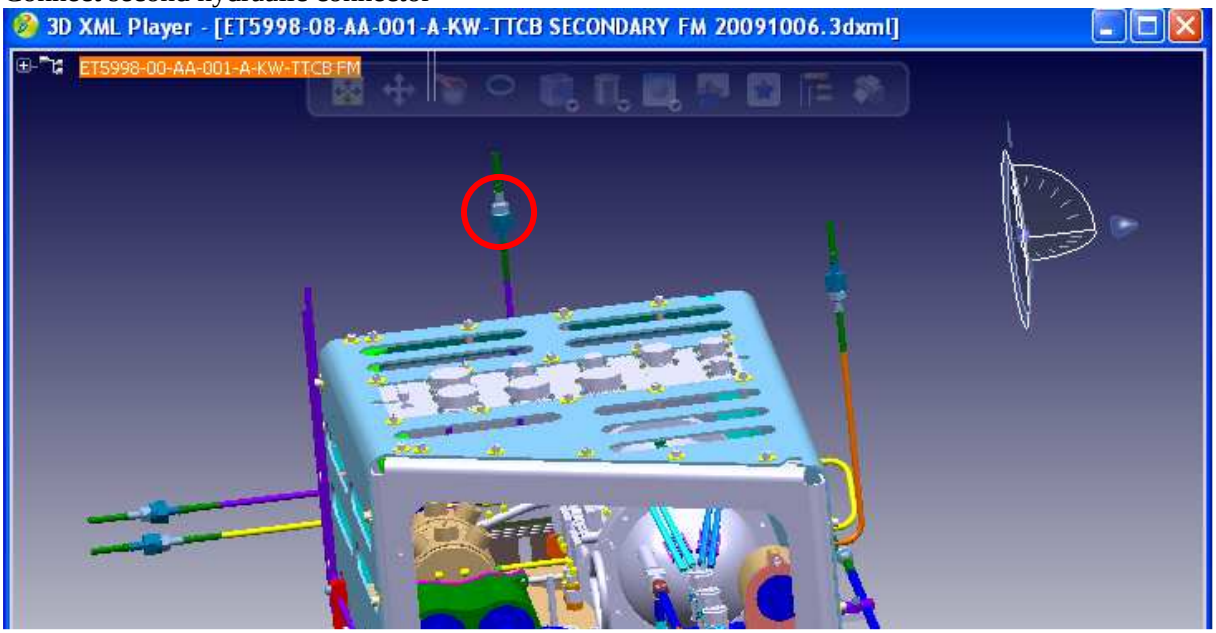


6. Connect purge lines as indicated (and close all other exits with caps or kapton tape)

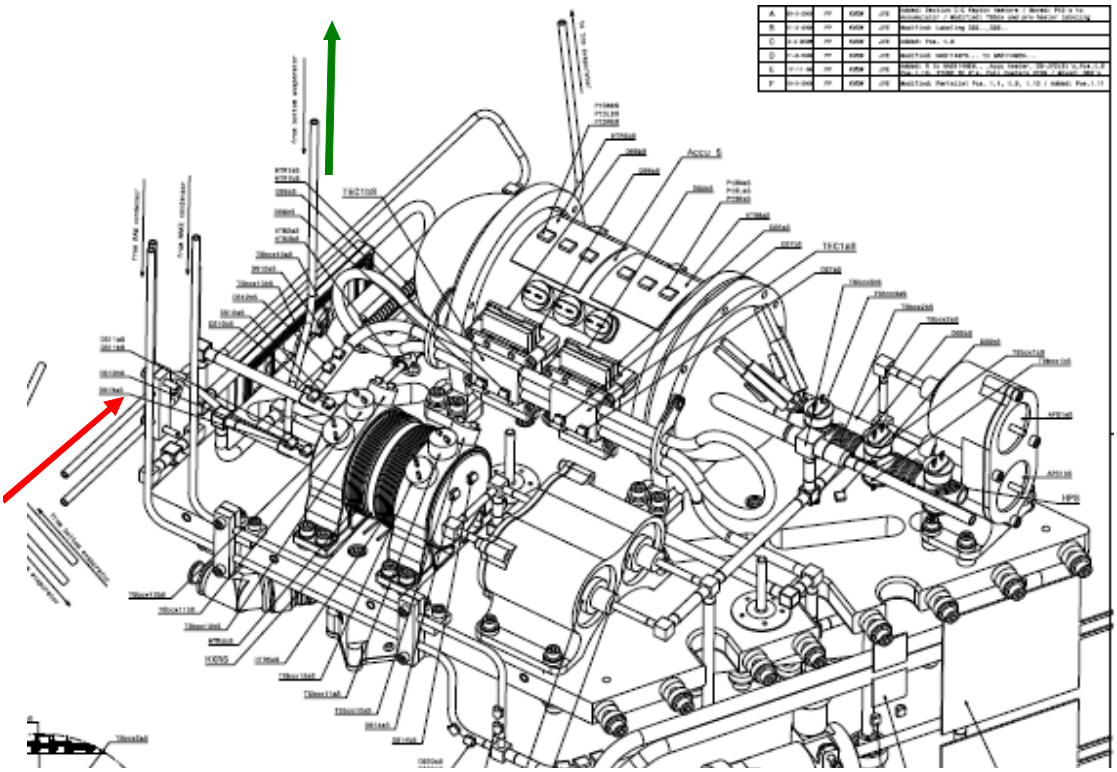


7. Perform weld

8. Connect second hydraulic connector

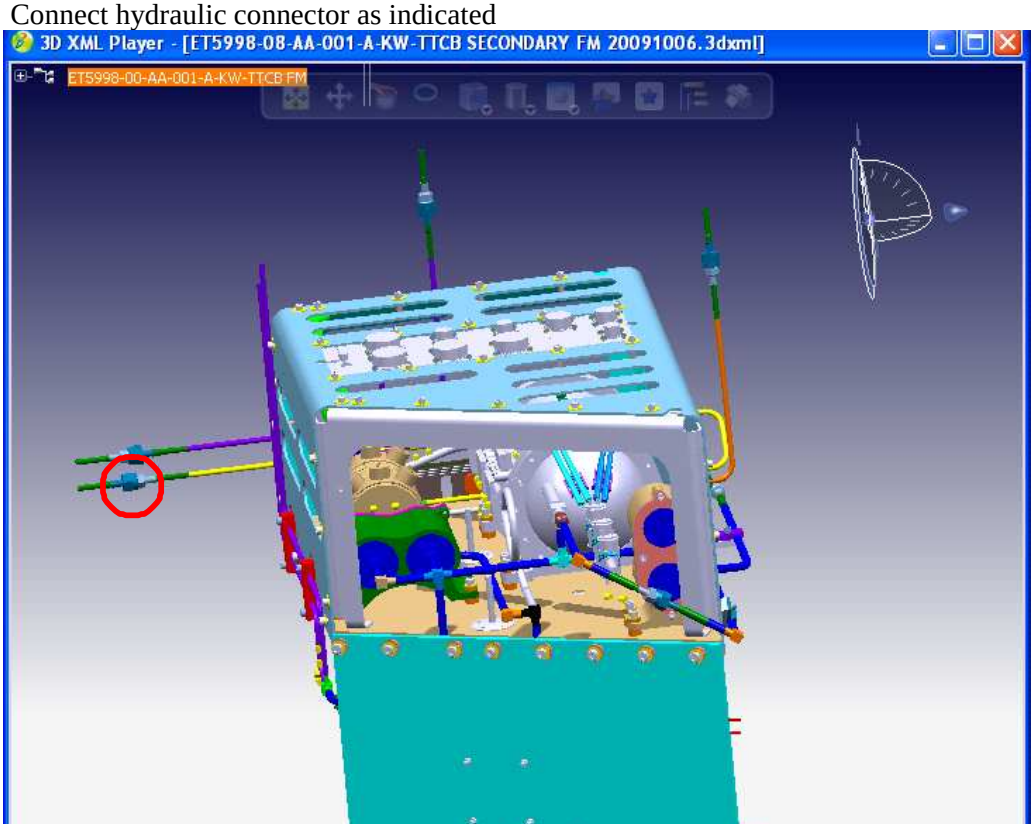


9. Connect purge lines as indicated

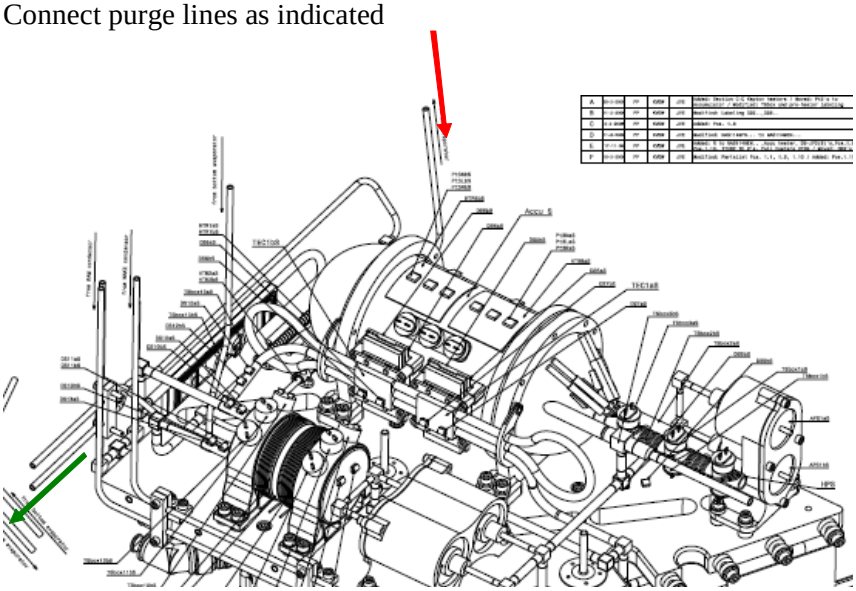


10. Perform weld

11. Close outlets with kapton tape to keep a shielding gas environment in the box.
12. Connect hydraulic connector as indicated

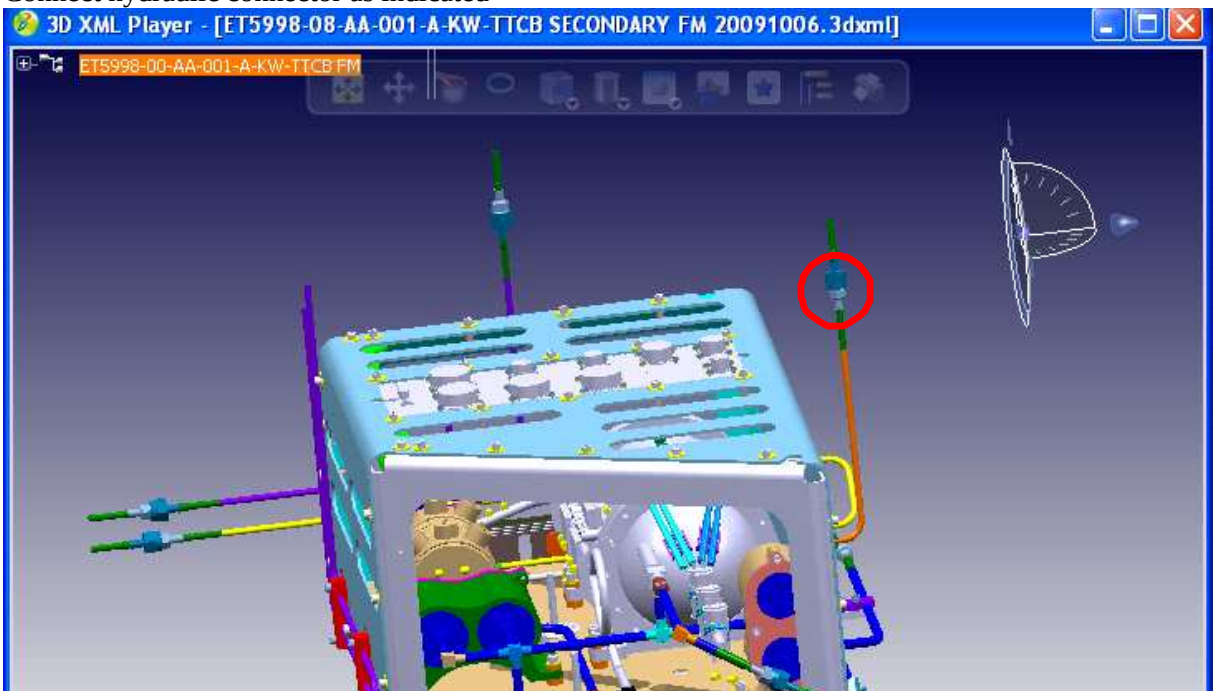


13. Connect purge lines as indicated

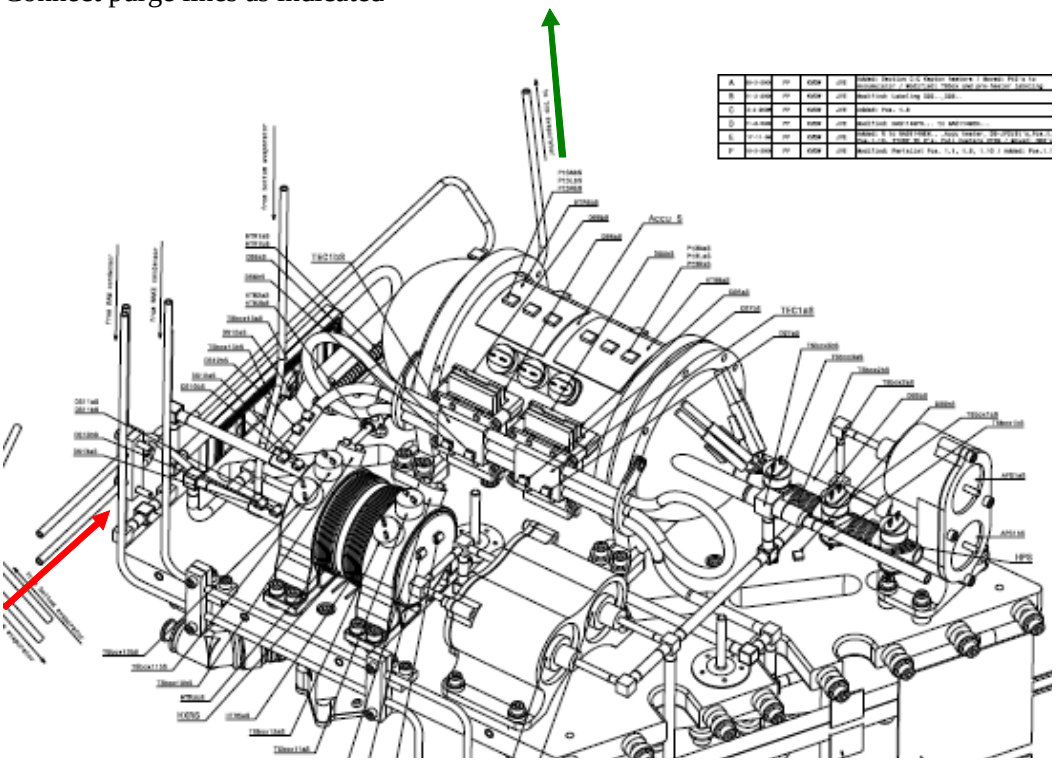


14. Perform weld

15. Connect hydraulic connector as indicated



16. Connect purge lines as indicated



17. Perform weld

9.2 TTCS-S off-line box tube welding 6 mm

Completely off line the inlet tubes are welded (according to procedures) and integrated on the boxes.

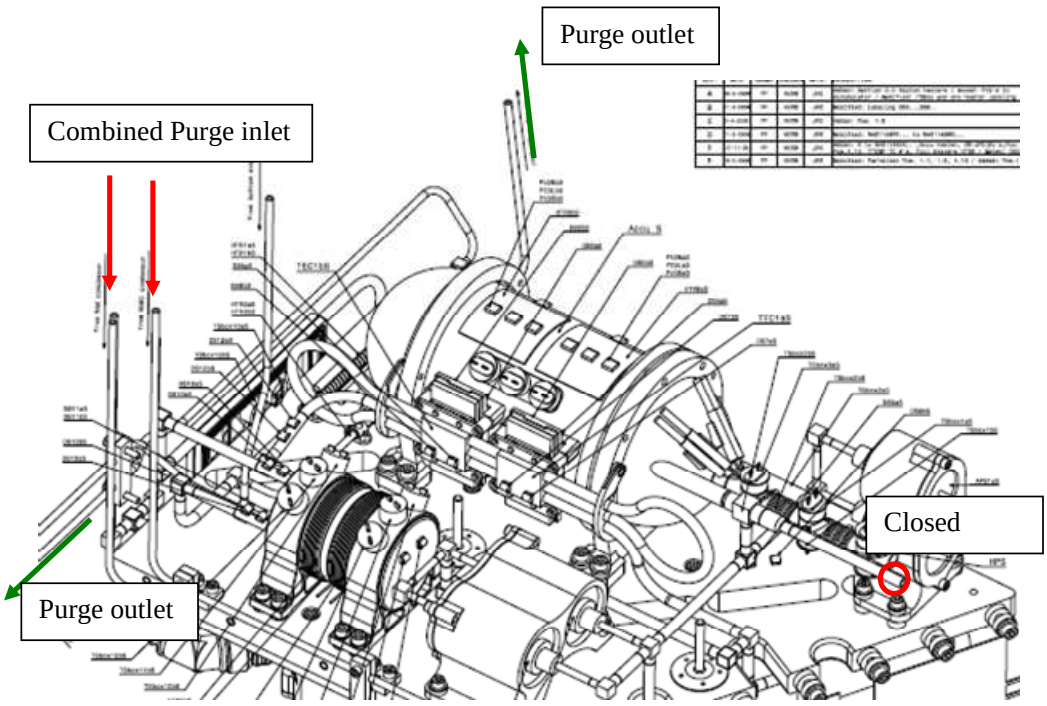
9.2.1 Filling TTCB accumulator with shielding gas

The TTCB accumulator and box will be filled with shielding gas prior to welding of the inlet tube.

This will be done either by vacuumizing the TTCB with a scroll pump and filling with shielding gas. Or the accumulator will be purged with shielding gas by using a capillary tube (cleaned with IPA). The accumulator opening will be slightly lifted such that the shielding gas will push out the air or CO2 in the system.

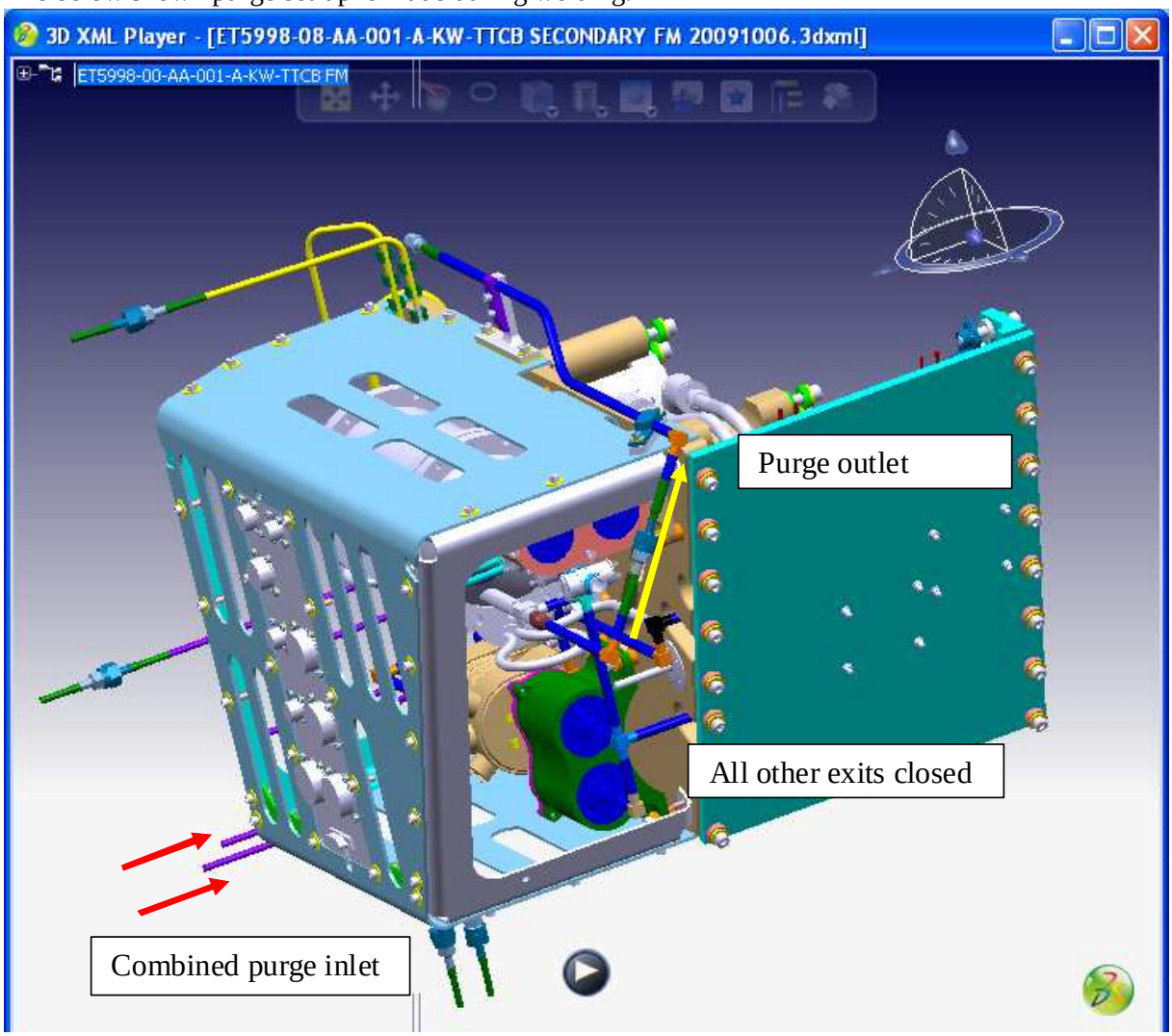
9.2.2 Inlet tube purge prior to welding

Prior to making the off-line weld to fill/pinch tube the tubing is purged. First the pump inlet tubes (from Wake condenser and from Ram condenser) are coupled via a T-branch and connected to the purge bottle. All other openings except the evaporator inlets are closed. Below the set-up is shown.



9.2.3 Purge set-up tube during welding

The below shown purge set-up is made during welding.



Perform weld.

Close ends before installing to keep as much as possible shielding gas inside the box.

9.3 TTCS-P off-line weld 6 mm

Just as for the Secondary box also for the Primary box the inlet tube assembly is welded completely off line (according to procedures) and integrated on the boxes.

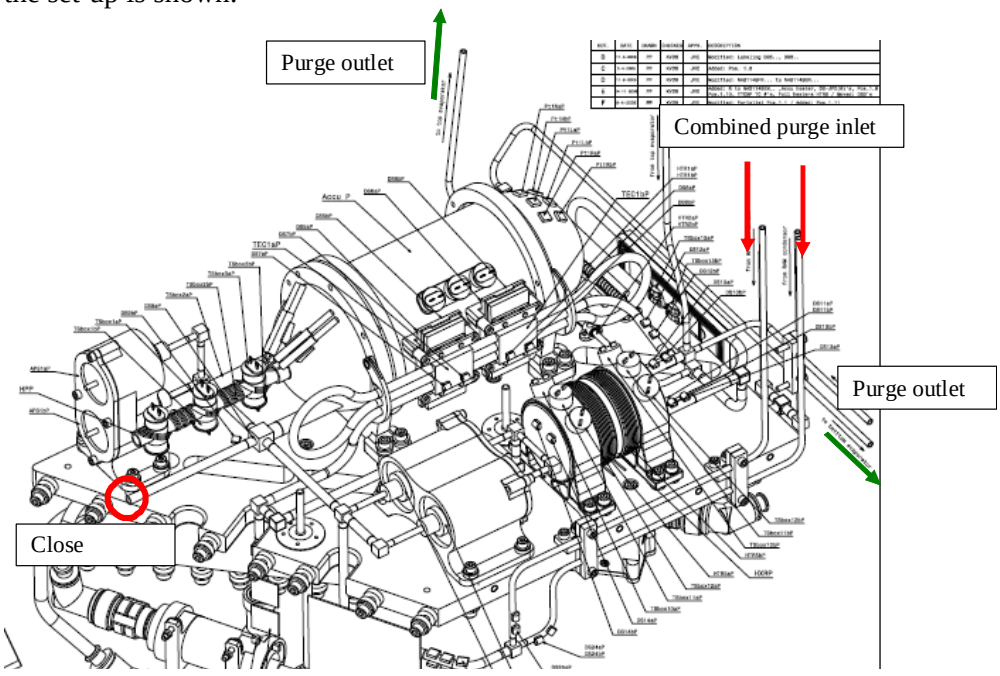
9.3.1 Filling TTCB accumulator with shielding gas

The TTCB accumulator and box will be filled with shielding gas prior to welding of the inlet tube.

This will be done either by vacuumizing the TTCB with a scroll pump and filling with shielding gas. Or the accumulator will be purged with shielding gas by using a capillary tube (cleaned with IPA). The accumulator opening will be slightly lifted such that the shielding gas will push out the air or CO2 in the system.

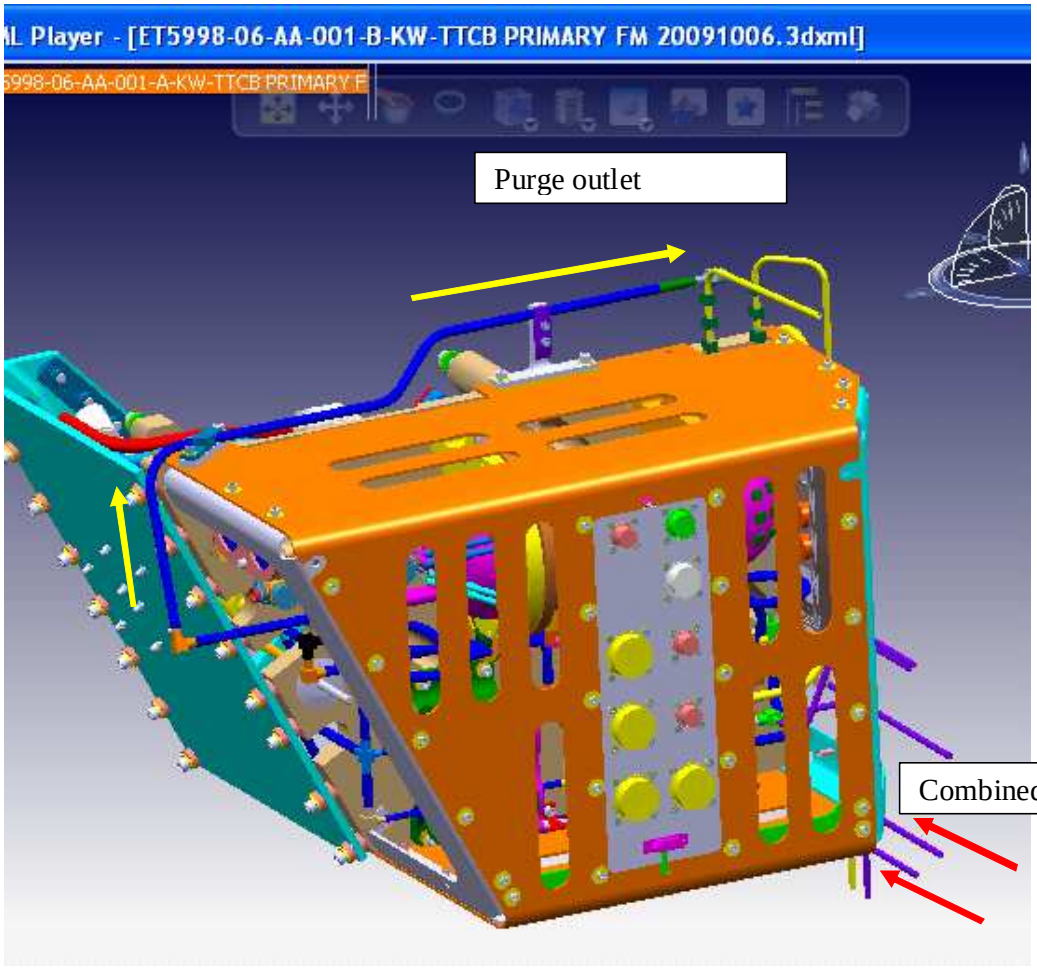
9.3.2 Inlet tube purge prior to welding

Prior to making the off-line weld to fill/pinch tube the tubing is purged. First the pump inlet tubes (from Wake condenser and from Ram condenser) are coupled via a T-branch and connected to the purge bottle. All other openings except the evaporator inlets are closed. Below the set-up is shown.



9.3.3 Purge set-up tube during welding

The below shown purge set-up is made during welding.



Perform weld

Close ends before installing to keep as much as possible shielding gas inside the box.

End of off-line welding

10 Purge set-ups during on-line welding

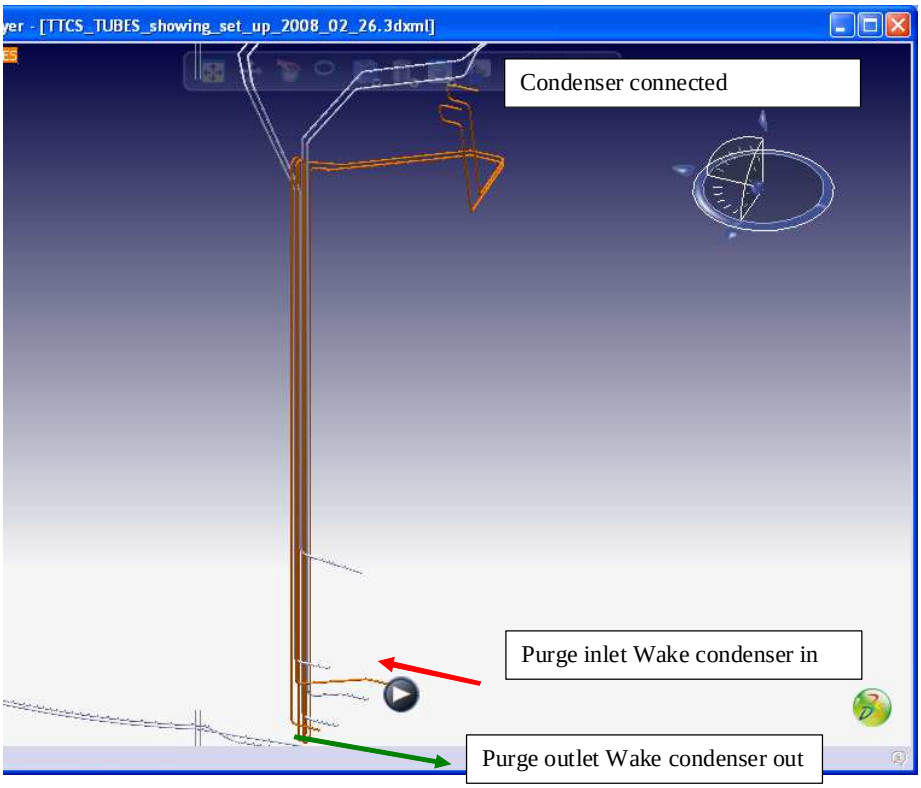
During on-line welding the distances of tubes can be very long. It is therfore important to take enough time to completely fill the tube with purge gas. The weld is always made at the outlet side of the purge (a large restriction downstream the pump is changing the weld conditions comapred to the weld qualification).

10.1 Purge set-ups during condenser to transport tube welding Secondary

Before final purging check via AMSTR-NLR-PR-076_TTCS_Loop_connection_check if the right connections are made.

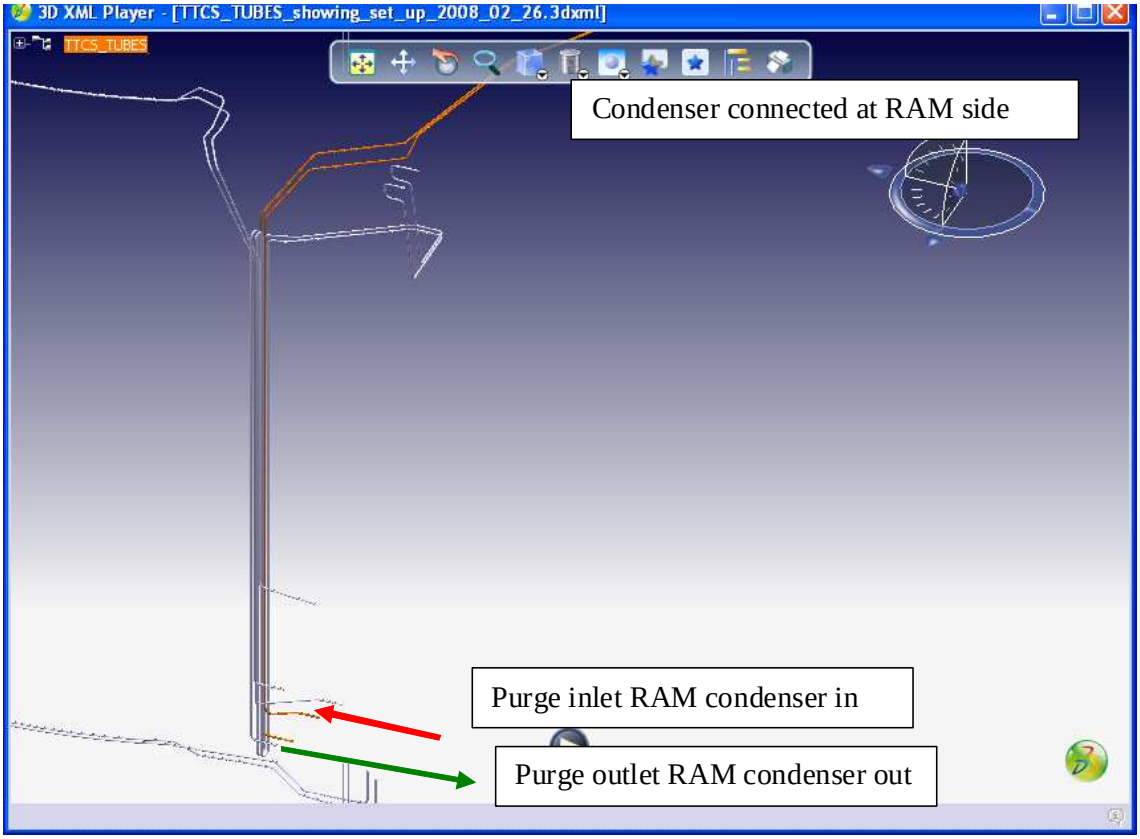
Remark: These are welds in long tubes. Be aware that the back pressure measurement could be different from the weld qualification. A test with large tubing before the weld sample will indicate the difference and give confidence in the set-up.

1. **Secondary WAKE condenser welds**
2. Install tube to condenser tubing by mechanical fixation or spot welding
3. Install purge set-up as shown below



4. Perform both welds in sequence
5. Close ends to keep purge as inside the tubes

6. **Secondary RAM condenser welds**
7. Install tube to condenser tubing by mechanical fixation or spot welding
8. Install purge set-up as shown below

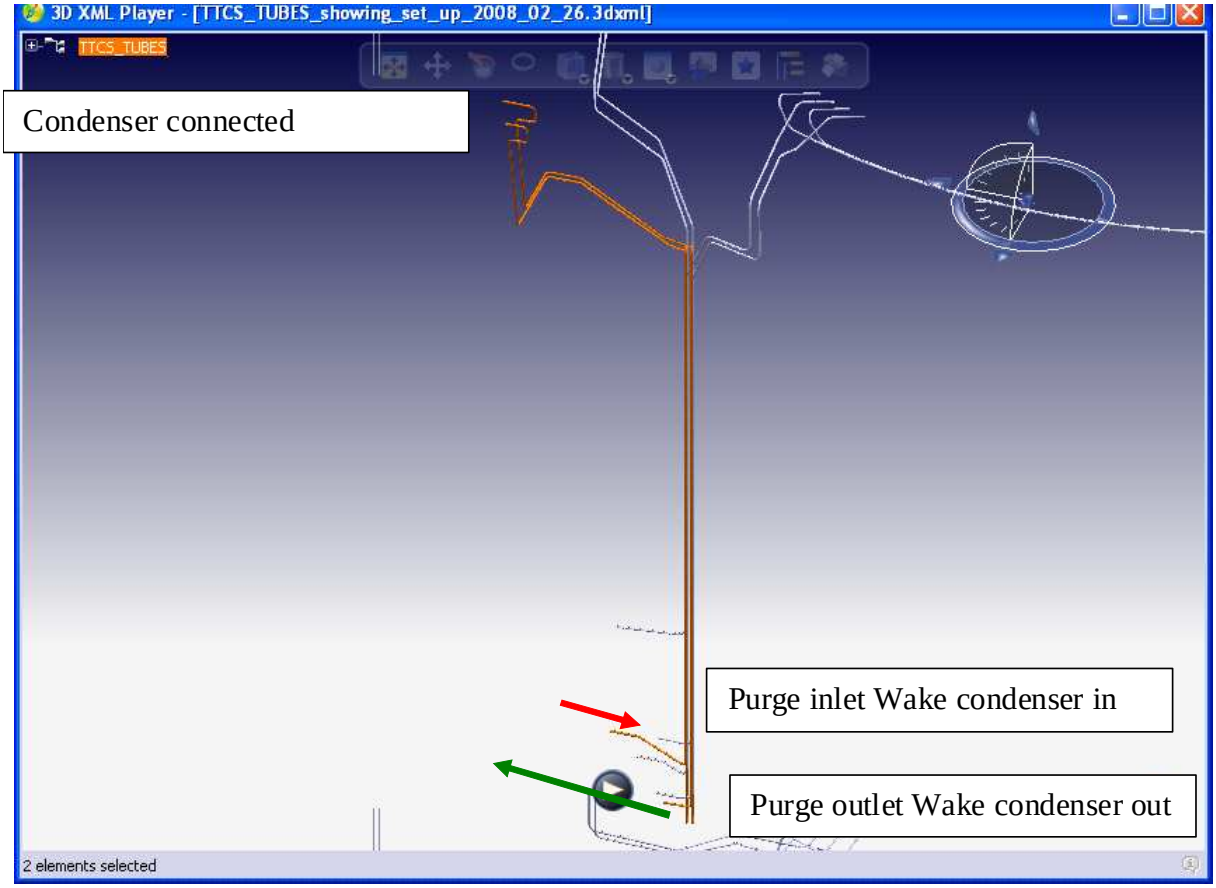


9. Perform both welds in sequence
10. Close tubes to keep weld gas in tubes

10.2 Purge set-ups during condenser to transport tube welding Primary

Before final purging check via AMSTR-NLR-PR-076_TTCS_Loop_connection_check if the right connections are made.

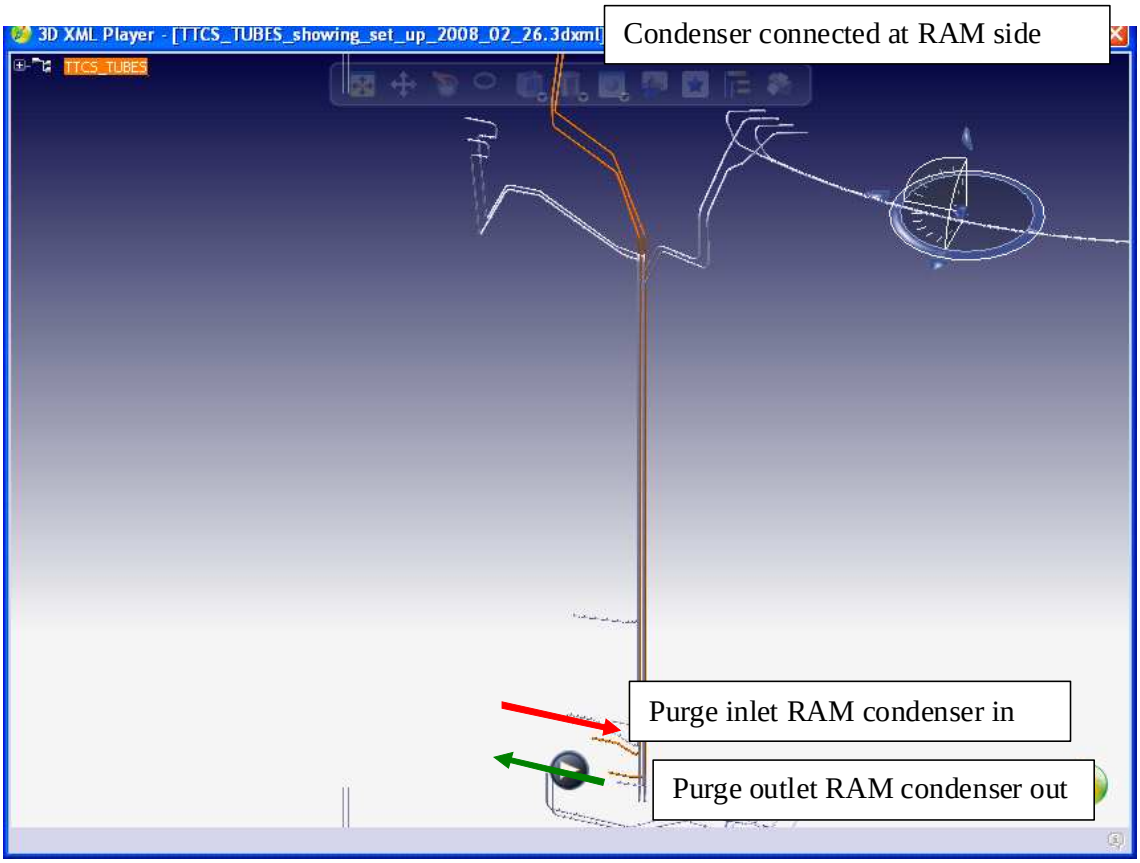
11. **Primary WAKE condenser welds**
12. Install tube to condenser tubing by mechanical fixation or spot welding
13. Install purge set-up as shown below



14. Perform both welds in sequence
15. Close ends to keep purge as inside the tubes

16. **Primary RAM condenser welds**
17. Install tube to condenser tubing by mechanical fixation or spot welding

18. Install purge set-up as shown below

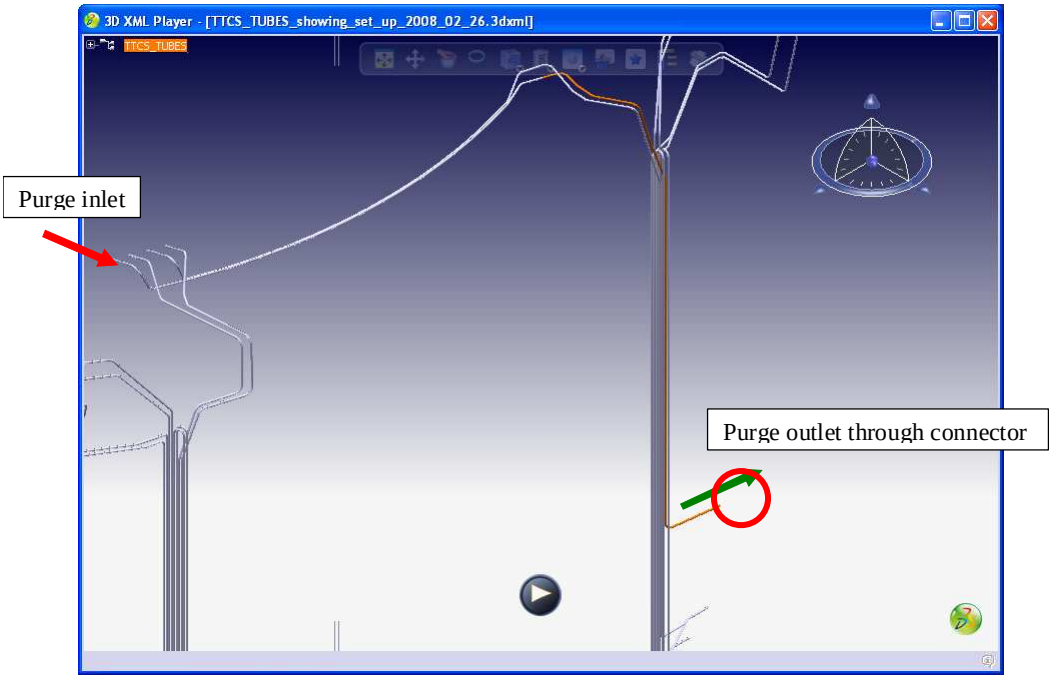


19. Perform both welds in sequence
20. Close tubes to keep weld gas in tubes

10.3 Purge set-ups for hydraulic connector to TTCS Secondary loop

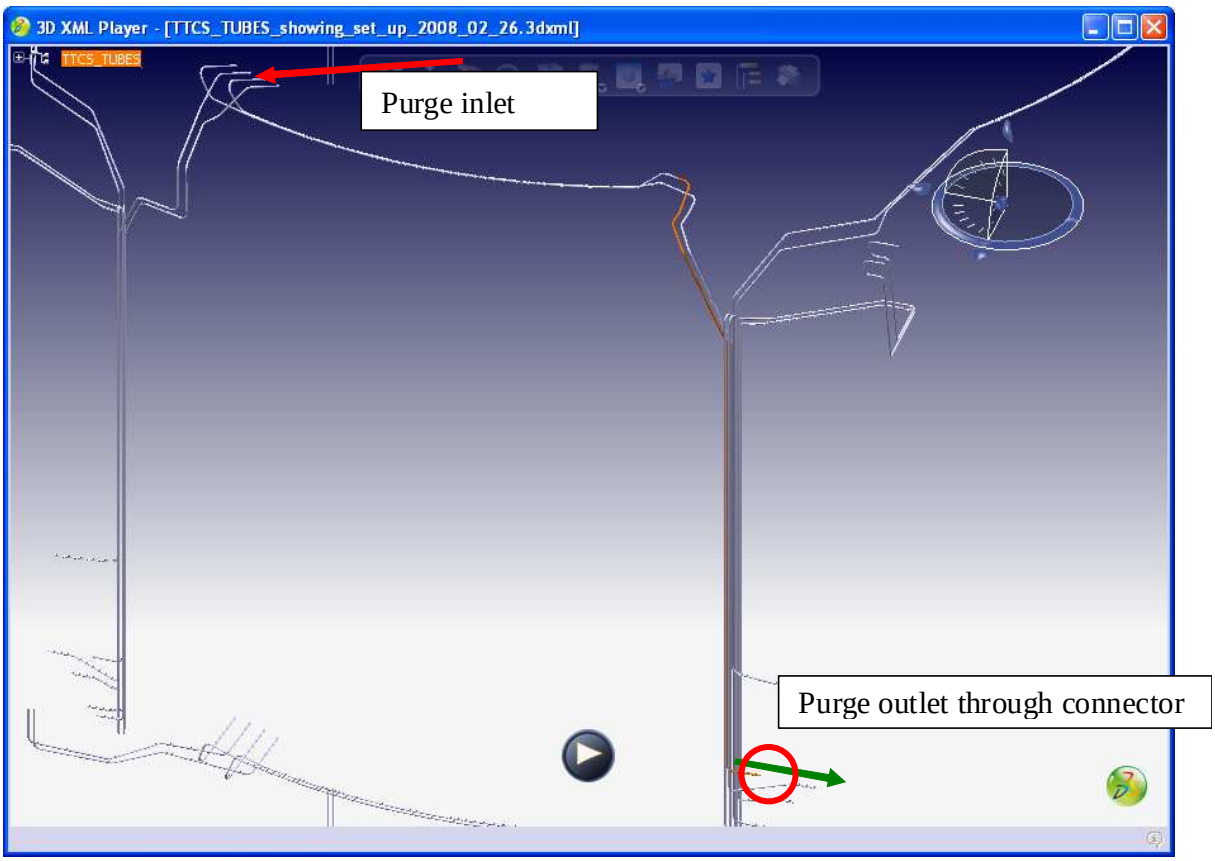
The hydraulic connectors for the connection of the

1. Use purge set-up connector Secondary top evaporator inlet hydraulic connector as shown below



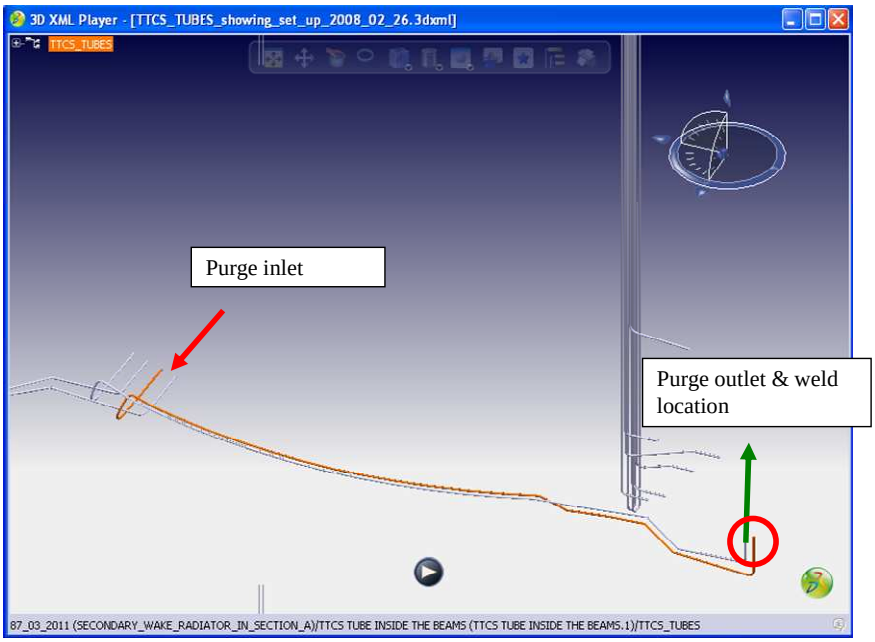
2. Perform weld
3. Close ends to keep purge gas in

4. Use purge set-up connector Secondary top evaporator outlet hydraulic connector as shown below:



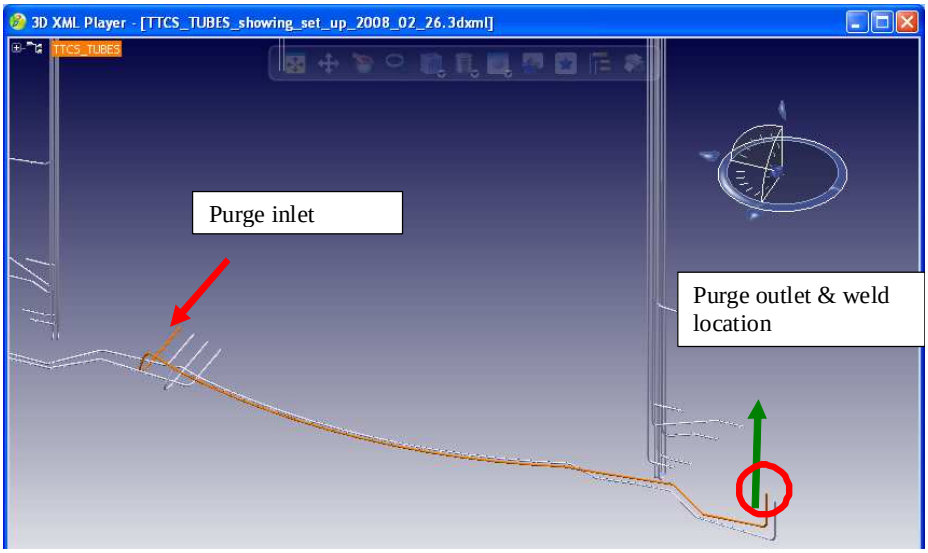
5. Perform weld
6. Close ends to keep purge gas in

7. Use purge set-up connector Secondary **bottom** evaporator **inlet** hydraulic connector as shown below



8. Perform weld
9. Close ends to keep purge gas in.

10. Use purge set-up connector Secondary **bottom** evaporator **outlet** hydraulic connector as shown below:



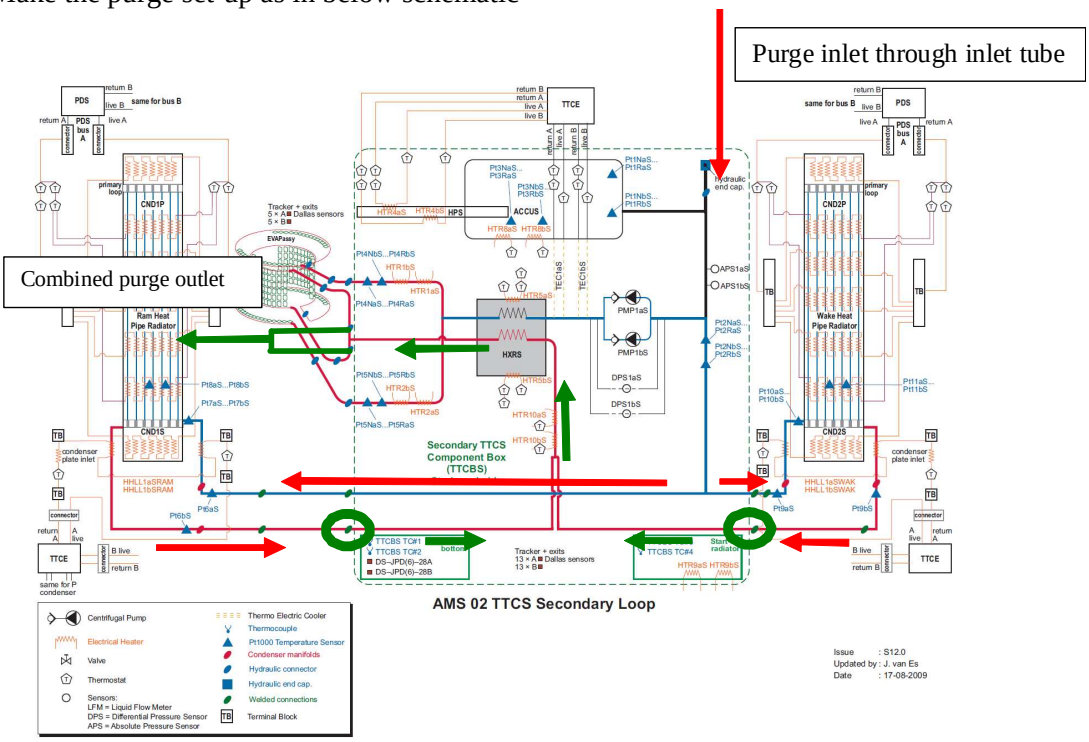
11. Perform weld
12. Close ends to keep purge gas in

10.4 Purge set-ups during Secondary box on-line welding

The condensers are already connected to the transport tubes. The boxes are integrated in place.

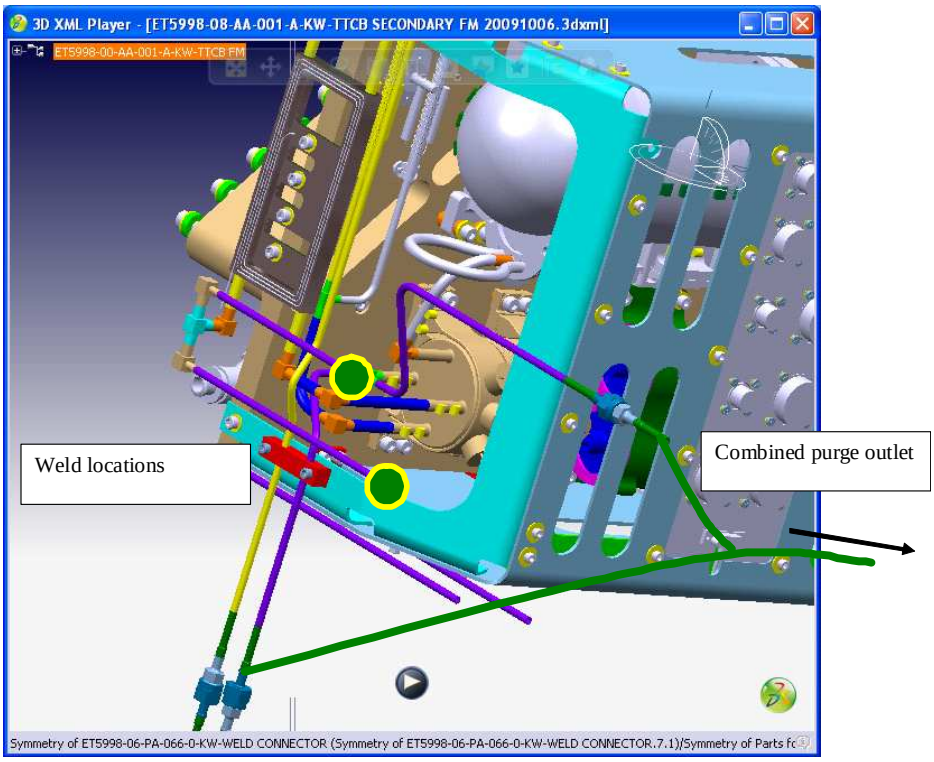
Steps

1. Fixate the tubes together
2. Make the purge set-up as in below schematic

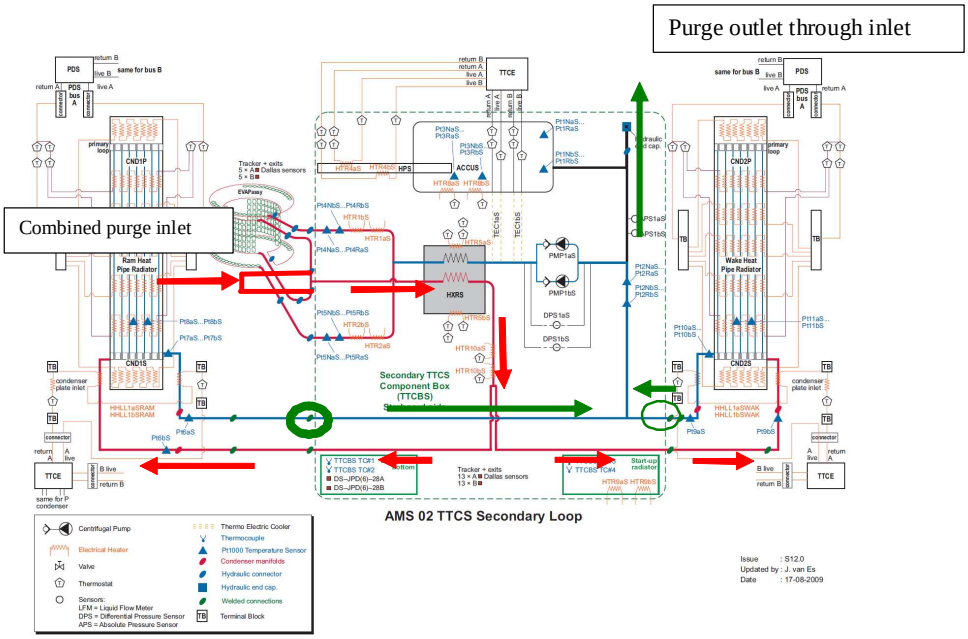


3. Connect the evaporator return lines by a T-split and put the back pressure sensor to the combined line

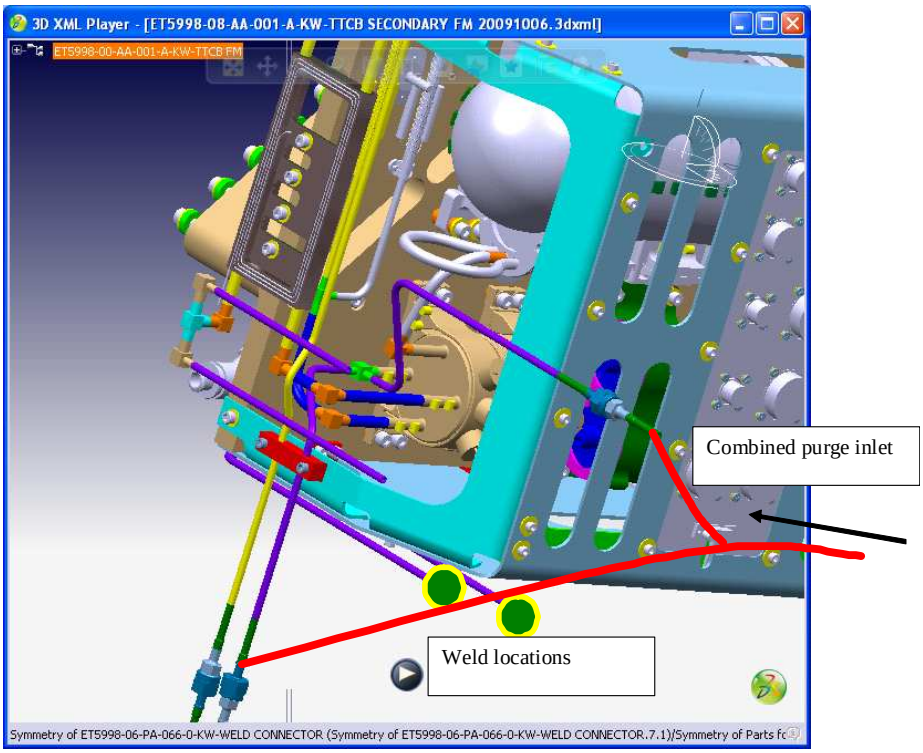
4. Fixate tubes on indicated weld locations



5. Perform both welds
6. Invert the purge gas direction



7. Fixate tubes on indicated weld locations

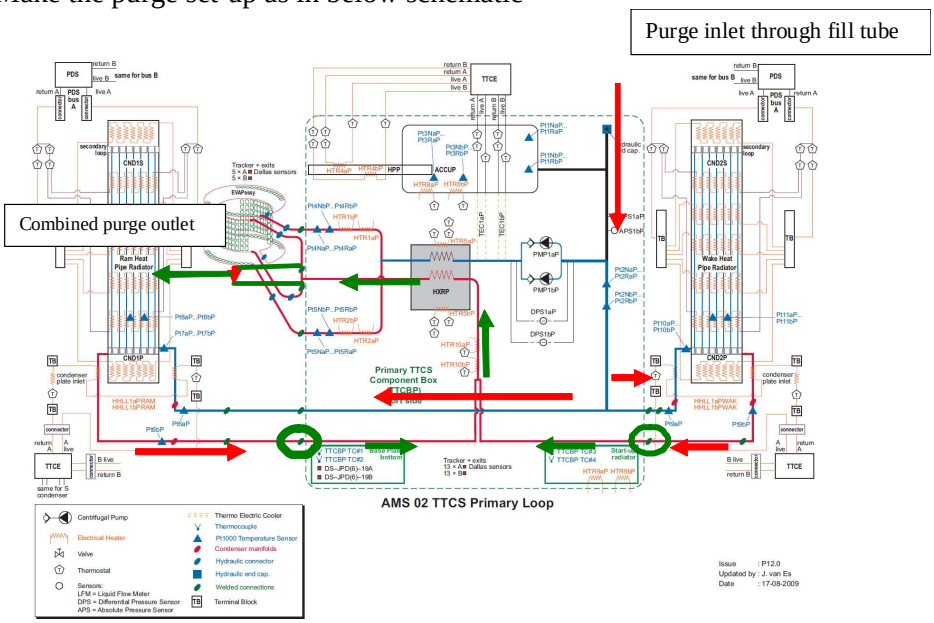


8. Perform both welds
9. End Secondary box welding

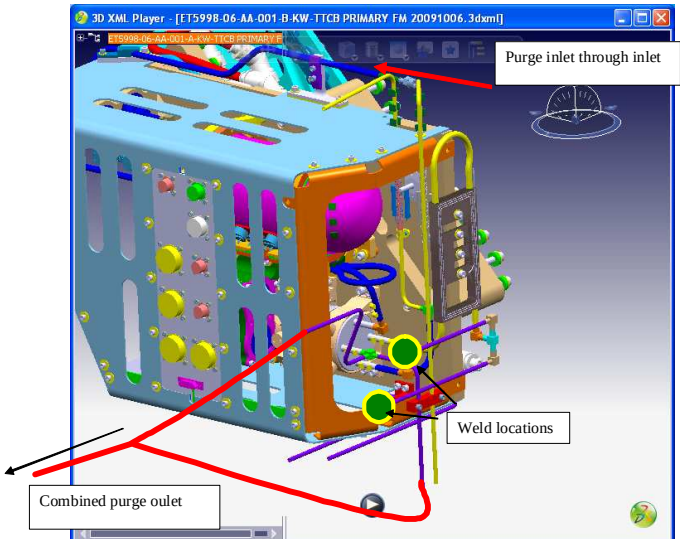
10.5 Purge set-ups during Primary box on-line welding

For primary box first the condenser inlet and outlet welds are made and finally the evaporator connections.

1. Fixate the tubes together
2. Make the purge set-up as in below schematic

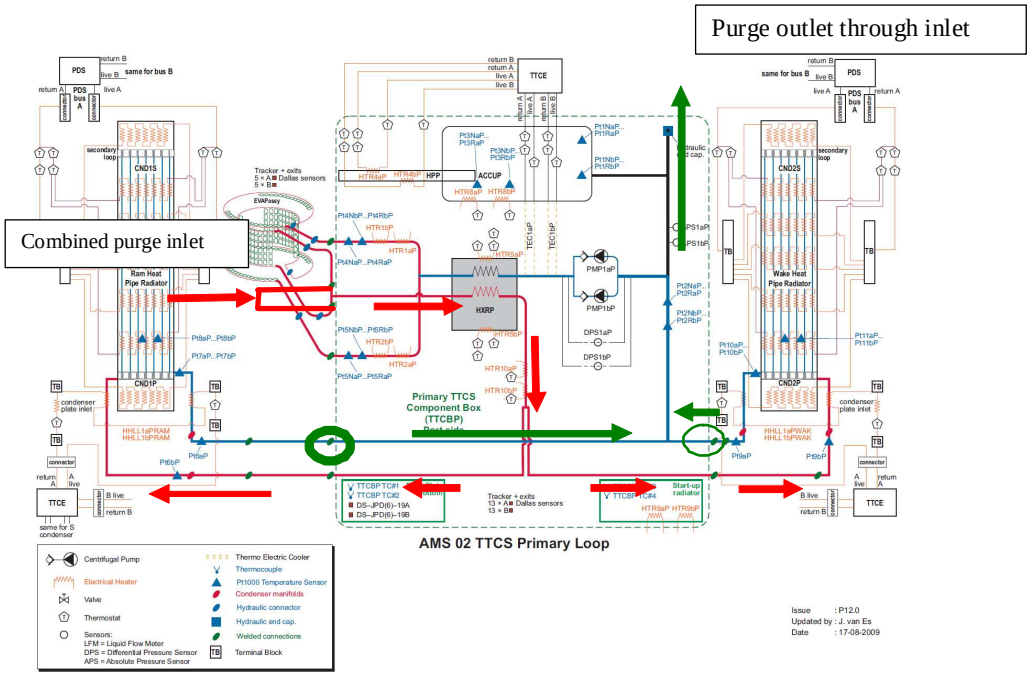


3. Connect the evaporator return lines by a T-split and put the back pressure sensor to the combined line

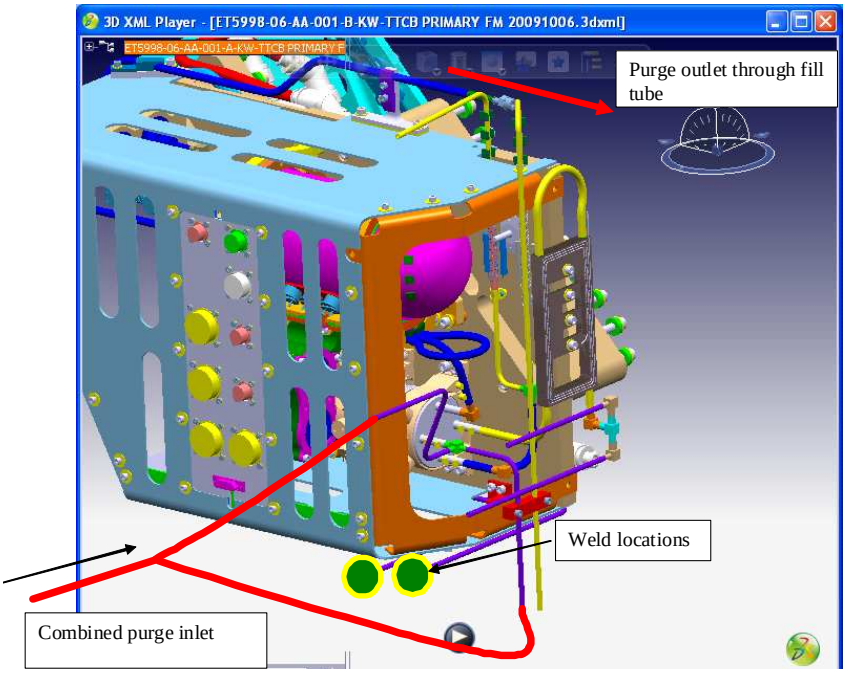


4. Fixate tubes on indicated locations

5. Perform both welds
6. Invert purge gas direction



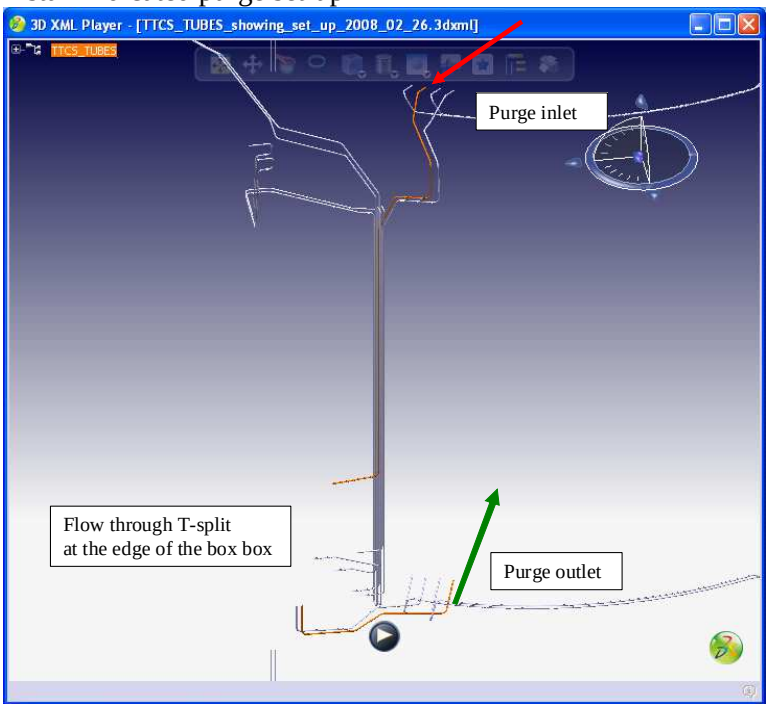
7. Fixate tubes on indicated weld locations



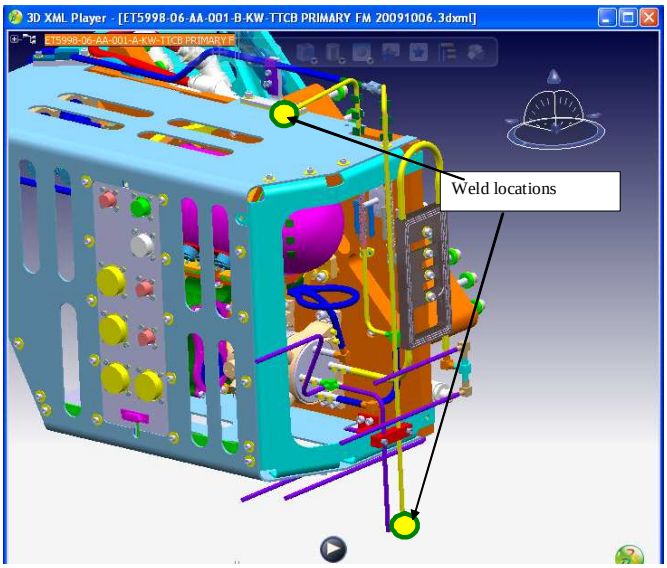
8. Perform both welds
9. Close ends to keep shielding gas environment inside the tubes

10. Evaporator tube connection welding

11. Evaporator inlet connections
12. Install indicated purge set-up

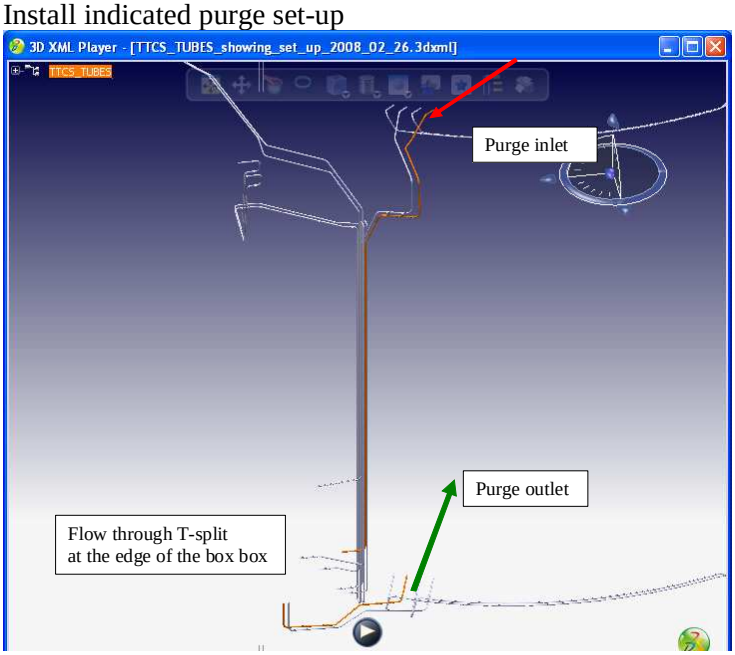


13. Purge to get a good internal shielding gas environment
14. Fixate tubes at weld locations

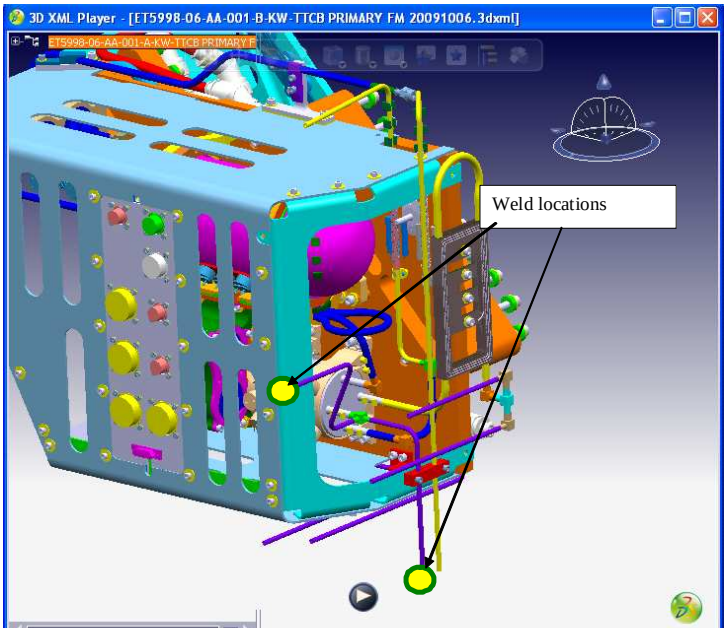


15. Perform indicated welds

16. Evaporator return connections
17. Install indicated purge set-up

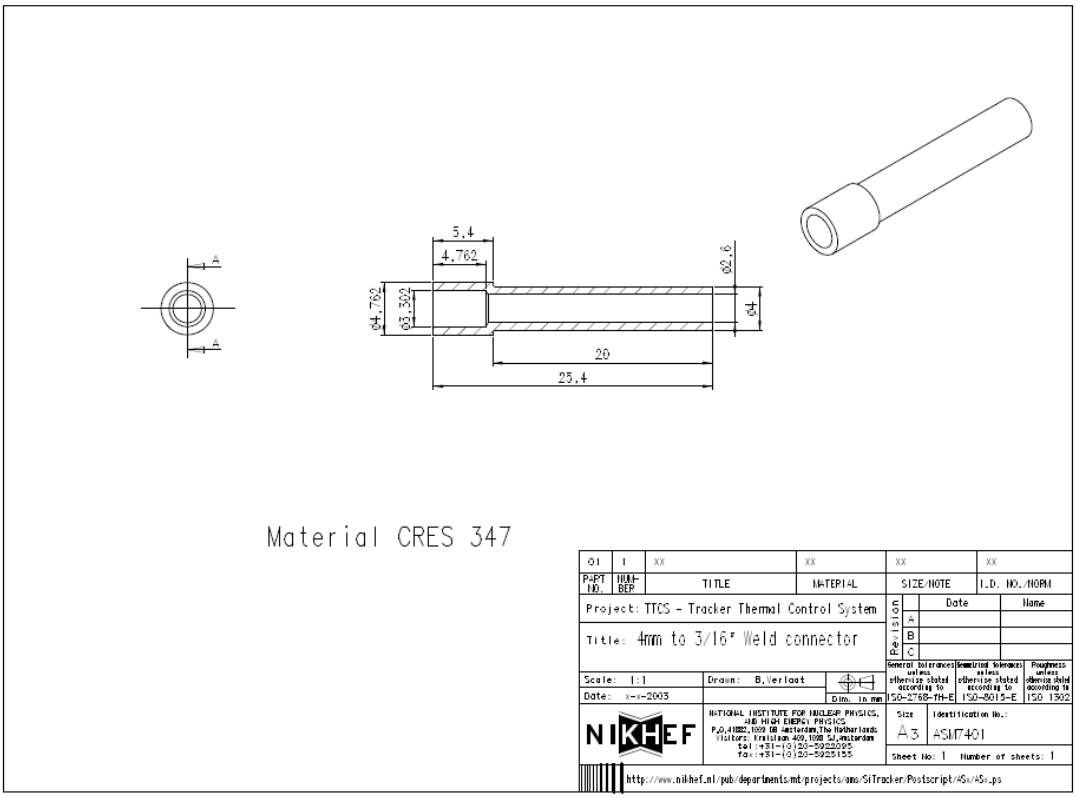


18. Purge to get a good internal shielding gas environment
19. Fixate tubes at weld locations



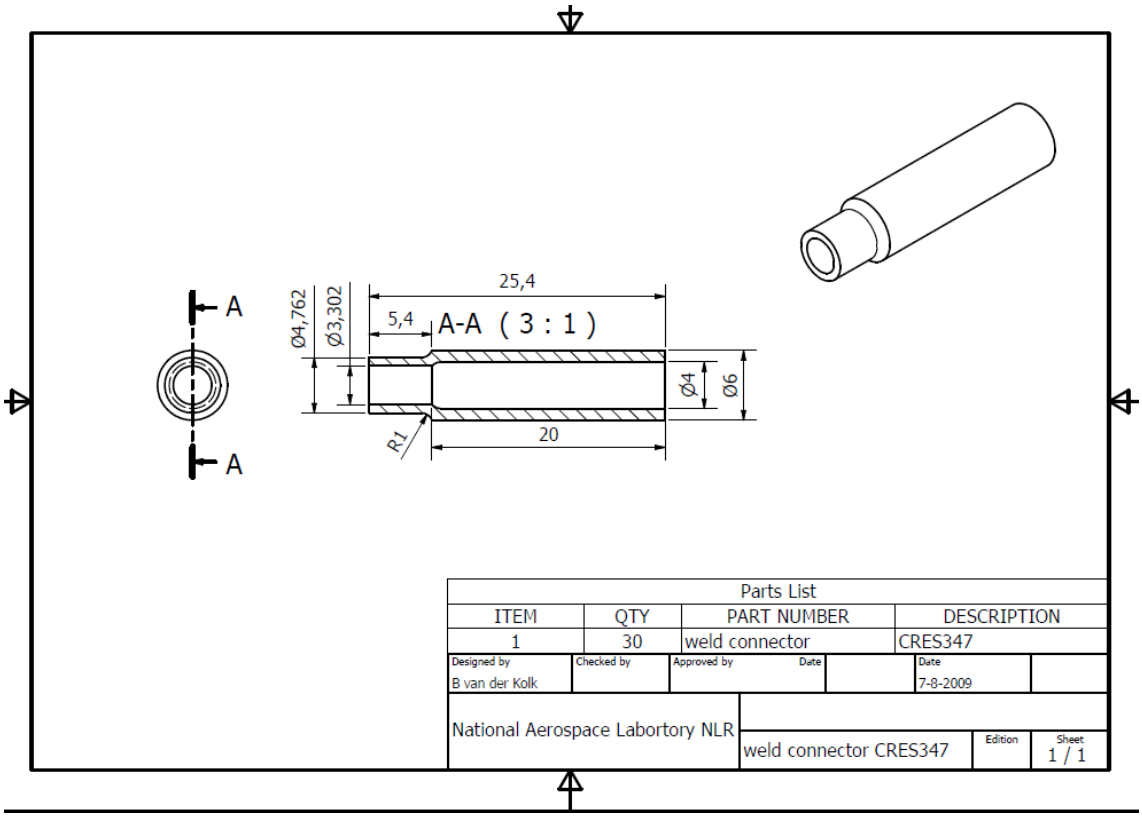
20. Peform indicated welds
21. End online welding

11 Appendix A: Intermediate tube section to 316L D_o= 4mm D_i = 2.6 mm



Intermediate section to standard TTCS transport tube D_o= 4mm D_i = 2.6 mm.

12 Appendix B: Intermediate tube section to 316L D_o= 6 mm D_i = 4 mm



Intermediate section to standard TTCS transport tube D_o= 6 mm D_i = 4 mm.

13 Appendix C: Tube and material certificates

DOCKWEILER
TUBE SYSTEMS IN STAINLESS STEEL
DOCKWEILER AG
An der Autobahn 10/20
DE-19306 Neustadt-Glewe

Dockweiler B.V.
Krachtenveld 53

NL - 3893 CD Zeewolde
NIEDERLANDE

Number of certificate pages: 1

Certificate Advice Note

Your Order:	08187 / 52180C
Your item:	001
Material:	Tube 6,00 x 1,00 1.4404 Ra <= 0,40µm / Ra(max.) <= 0,48µm
Quality:	TCC.1
Quantity:	53.91 m
Dockweiler-no.:	P46346
Job-no.:	06576031
Job-no. of prematerial(s):	05475481
Heat(s):	505204
Our order no.:	AUF07047688
Our delivery note no.:	LFS07067082
Our delivery item no.:	001
Delivered on:	2007-11-02

This document was created electronically and is valid without signature.

We herewith confirm that the product supplied is in conformity with thedemands of the specification and agreements in the order.
Statement on QA system acc. to EN 764-5 (1/2003)
Certified by TÜV Nord on the basis of 97/23/EC, Annex I, Section 4.3,Certificate No.: 07 202 3537 Z 0509/54
Scope of application: T-piecesbacks on tubes of austenitic material,Diameter 17-170 mm, wall thickness 1.0-3.5mm
Date of expiry: 02/2008

Statement on welding procedures and welders' exams:
Approval of welding process by TÜV Nord, Cert. No. 07202303700965/2/V/01-03, Test standard: 97/23/EC, AD2000 HP2/1, EN 288-3
Scope of application: Diameter 3-370 mm, wall thickness 0.7-3.05 mm
Welders' exams by TÜV-Nord, Test standard: 97/23/EC, AD2000 HP3, EN287-1 and EN1418

pre-material certificate 3.1 is attached

Start of Page : 1 of : 1

FINE TUBES LIMITED
PLYMBRIDGE ROAD, ESTOVER, PLYMOUTH PL6 7LG
Telephone: Plymouth +44 (0) 1752 735851
Fax: +44 (0) 1752 733301
Sales: +44 (0) 1752 697216

finetubes

Test Certificate Number 096422

Customer Order No. **P46346/05003579*001** Fine Tubes Reference No. **206486** Works Order No. **T206486*1** Customer Part/Drawing	Customer **DOCKWEILER AG** **AN DER AUTOBAHN 10/20** **19306 NEUSTADT-GLEWE** **GERMANY** Dimensions **O.D. 6.0000 mm** **Wall 1.0000 mm**	Material Designation **WERKSTOFF 1.4404 / 316L** Form **DRAWN SEAMLESS TUBE** Temper **BRIGHTANNEALED 180HV(80HRB)MAX** Quantity **1084.190 MTR** Pieces **181**

Specification

DOCKWEILER 2250 'DX' ULTRON BASE
DIN 17458 ASTM A269/A213

Chemical Analysis

Cast/Heat No.-505204 Melter SANDVIK
Extruder SANDVIK

	C	Mn	P	S	Si	Ni	Cr	Mo	Ti	Al
	%	%	%	%	%	%	%	%	%	%
Top	0.006	1.64	0.029	0.011	0.34	11.2	16.87	2.07	0.005	0.003

	Co	Cu	N2	B	Ca					
	%	%	%	%	%					
Top	0.099	0.31	0.061	0.0009	<0.0005					

Mechanical Properties

Tensile Stress (Rm) (MPa)	0.2% Proof Stress (MPa)	1% Proof Stress (Rp:1.0) (MPa)	% Elongation 2"	% Elongation 5.65√So	Hardness HV/5.0	Hardness HRB Converted
620	279	308	50	52	174-175	76.1-76.5
618	277	310	50	53		

Tests Performed And Accepted

Intercrystalline Corrosion	Satisfactory	I/D Surface Roughness Ra	0.18 æm
Flattening	Satisfactory at 4 mm	Material Verification	Satisfactory
Flare Test	Satisfactory at 8 mm	Eddy Current Test	Satisfactory
O/D Surface Roughness Ra	<0.8 æm	Visual Assessment	Satisfactory

Additional Information

This material meets the chemical and mechanical property requirements of ASTM A269, ASTM A213 average wall, ASME SA213 average wall and DIN 17458 Test Class 1.
Annealed at 1040 degrees C.
Electric melted material.
NACE MR 0175-2003.

Declaration Information

Certified that, unless otherwise stated above, the whole of the Materials detailed hereon have been Manufactured,Tested and Inspected in accordance with the terms of the Contract/Order applicable thereto, and fully conform in all respects to the Standard Specifications and:
BS EN 10204:2004 Type 3.1 / DIN EN 10204:2004 Type 3.1.
in accordance with PED 97/23/EC Registration Number 04/202/2/430/0204027.

Dockweiler AG
Job-Nummer:
0547548 1
Seite/Page 1 / 1
Pers.-Nr. 210

FM 09729 EMS41528

Ian Olney
Quality Certification Representative 10/03/06

End of Page : 1 of : 1

6 mm standard Dockweiler tubes

4 mm OD stainless steel box standard tubing

Abnahmeprüfzeugnis / Inspection Certificate | DIN EN 10204 / 3.1 B | Zeugnis - Nr. 23277

UTI-SFM Feinmechanik GmbH, Staatsstrasse 5, D-97773 Aura

Merinox B.V.
Postfach 23

NL-2950 Alblasserdam

Kundenauftrag: Your order: 20030089 vom 20.02.03
Unser Auftrag Our order: CF000680
Lieferbedingung: Terms of Delivery: Lt. Auftragsbestätigung
Lieferzustand: Delivery state: geglüht
Besondere Vereinbarungen: Special terms: Nahtlose Rohre gem. DIN 17458 Pk. 1, außer Punkt 5.3.2 und 6.3.1.6 (Verwechslungsprüfung)

Prüfgegenstand: Nichtrostende Rohre / Rohrformteile
Object: Stainless steel tubes / fittings
Werkstoff: Material: 1.4404 nahtlos

Position Item	Menge: Quantity	Abmessung (mm) size (mm)	Toleranzen Tolerances	
2	12,98 kg = 236 m	4,00 mm Ad. x 0,70 mm Wdd.	D4 T3	

Mechanische Werte / Mechanical Properties

Position Item	Zugfestigkeit Tensile strength Rm N/mm²	Streckgrenze Yield strength Rp 0,2 N/mm²	Dehnung Elongation %	Härteprüfung Hardness Vickers 0,5	Dichtheitsprüf. Leak proof test bar	Rauhigkeit. Roughness my	
1	668	319	56,96				
2	632	373	65,07				

Chemische Zusammensetzung des Einsatzmaterials Chemical composition (according to works certificate of steel mill) — Schmelz - Nr.: Cast No.: 453768

C %	Si %	Mn %	P %	S %	Cr %	Mo %	Ni %	Ti %	Fe %	Al %	N %	Cu %
0,018	0,390	1,700	0,032	0,008	17,01	2,05	11,38				0,063	0,30

Ringaufdornversuch: Ring expansion test:
Kennzeichnung: Marking:
Sicht- und Maßkontrolle: Visual inspection and control of dimension: o.B.
Andere Prüfungen: Other tests:

UTI-SFM Feinmechanik GmbH
Zertifiziert nach DIN EN ISO 9002: 1994
Qualitätsstelle

97773 Aura, 16.05.03

Abnahme: Werkssachverständige

Wir bestätigen, daß die oben aufgeführten Rohre den Lieferbedingungen entsprechend geprüft u. in Ordnung befunden wurden.
It is certified that the tubing listed as above has been tested in accordance with the terms of delivery and found satisfactory.

VD-85-3 (QS) Änderung: d Elektronisch erstelltes Formular

NIKHEF batch (TTCB side)

MicroGroup, Inc.
7 Industrial Park Road
Medway, MA 02053-1732
Ph: 508-533-4925 / 1-800 ALL-TUBE
Fx: 508-533-5691

MicroGroup
www.microgroup.com

Customer: CERN
Address 1: BUILDING 867
Address 2: OFFICE: R-H75
City: CEDEX
Prov/ST: -
Zip/Postal Code: F-01631

Certification Group: 14820
Certification: 14820
Cust PO: Prepay
MG Order: MG00048524-1
Cust Dwg/PN: Material Clean Footage
MG Item: MAT-CLEAN-FT
MG Job: CJ00006321-0
Date: 03/26/2009
Manufactured Lot: 946690
Material Item: 316F10156X028SL
Material Lot: R00000000002976
Quantity: 260.00

Certification of Compliance / Material

We hereby certify that all the items in the shipment have been produced, inspected and found to be in compliance with the applicable drawings, military specifications and/or standards, and purchase order requirements. All documents utilized were to the revision identified in the purchase order or as specified by the buyer. Substantiating records are on file subject to review upon request.
Where applicable, Microgroup also certifies that the heat numbers and analyses detailed herein are correct as contained in the records of this Corporation. Because the MicroGroup has no control over the subsequent processing of product application, the MicroGroup expressly disclaims any and all expressed or implied warranty other than the warranty herein set forth below. Such disclaimers include without limitation, warranty, or fitness for particular purpose and warranty of workmanship.

Authorized Signature: Mark S. Hindley
Mark S. Hindley
Title: Quality Control Supervisor

Physical Properties:

Mat'l	Grade	Mfg Type	Category	Gauge	IPS	Schedule	L Grade	Surf Cond
Stainless Steel	316	Seamless	Fractional				Yes	Bright
OD Max	**OD Min**	**ID Max**	**ID Min**	**Wall Max**	**Wall Min**	**OD Finish**	**ID Finish**	**Length**
0.1584	0.1580			0.0272	0.0268			

Chemical Properties:

C%	Mn%	P%	S%	Si%	Ni%	Cr%	Mo%	Cu%
0.0200	1.7200	0.0310	0.0030	0.3700	12.3000	16.5700	2.0700	0.1700
Ti%	**Cb%**	**Co%**	**Al%**	**N%**	**Fe%**	**Other%**	**Other%**	**Heat#**
0.0000	0.0000	0.0000	0.0000	0.0082				V00647

Mechanical Properties:

Temper	Ultimate Tensile (PSI)	Yield Strength (PSI)	Hardness	Elongation % in 2"	Embrittlement	Eddy Curr	Bend	Rev Bend
Annealed	78,000.00	31,900.00		53.00		Y		
White Cloth	**Flange**	**Flare**	**Hydro**	**Passivity**	**Grain Size**	**Micro**	**Flattening**	
			Y					

Specifications:

ASTM1	ASTM2	ASTM3	AMS1	AMS2	AMS3	MILT1	MILT2	MILT3
A269-98	A213-99A							

Additional Comments:

PARTS HAVE BEEN PICKLED
PARTS HAVE BEEN RINSED WITH DIONIZED WATER

Country of Origin:

Manufacturing:
Melt Source:

Created By: parvanitakis

Microgroup batch (transport tubes side)

Swagelok

Swagelok Company
29500 Solon Rd
Solon, OH 44139
U.S.A

440.349.5600
440.519.4997 fax

Certificate of Compliance/Typical Material Certification (EN 10204-2.2)

Distributor	Customer	Customer PO#
Nederland Sales & Service B.V. Coenecoop 770 2741 PW Waddinxveen P.O. Box 93 The Netherlands	National Aerospace Department (NLR) Postbus 153 8300 AD EMMELOORD	Weld Couplings

No.	Part Number	Qty
1	6LV-6MMW-9	62

Swagelok products referenced above are manufactured from material purchased and certified as being in accordance with the specification(s) listed.

Stainless steel material has passed the Intergranular Corrosion Test requirements of EN ISO 3651-2, Method A, and/or ASTM A-262 Practice A or E.

All parts were cleaned and packaged in accordance with Swagelok Specifications.

Typical mechanical and/or chemical analysis of the material used in the manufacture of the Swagelok products involved are listed below. These values are average values determined from a sample of certified material test reports. Actual values for a material heat may vary from those indicated.

MATERIAL STANDARDS

Components	Material	Standards
Micro-Fit Weld Fittings	316L VIM VAR Stainless Steel Bar	SEMI F20 (with exception of 20% min. elongation)
Shaped Micro-Fit Weld Fittings	316L VIM VAR Ultra High Purity Stainless Steel Bar	SEMI F20 (with exception of 20% min. elongation)

MECHANICAL PROPERTIES

Components / Materials	Yield Strength (ksi/MPa)	Tensile Strength (ksi/MPa)	Elongation (%)	Hardness
Micro-Fit Weld Fittings	97/669	115/793	23	HRC 22
Shaped Micro-Fit Weld Fittings	97/669	115/793	23	HRC 22

CHEMICAL ANALYSIS

Components / Materials	Al	C	Co	Cr	Cu	Mn	Mo	N	Nb	Ni
Micro-Fit Weld Fittings	0.002	0.018	0.02	17.48	0.03	0.31	2.67	0.010	0.01	13.50
Shaped Micro-Fit Weld Fittings	0.002	0.016	0.01	17.68	0.03	0.30	2.63	0.007	0.01	13.55

Components / Materials	P	S	Si	Ta	Ti	V	W	Ca	Cb	Fe
Micro-Fit Weld Fittings	0.009	0.006	0.32	0.01	0.01	0.03	0.02			
Shaped Micro-Fit Weld Fittings	0.005	0.006	0.15	0.01	0.01	0.01	0.02	0.01	0.01	65.59

The Swagelok product specified above were manufactured in accordance with Swagelok Company's Quality Assurance Manual (latest revision, revision G, dated February 22, 2006). Swagelok Company's Quality System is approved to ISO 9001 (BSI Certificate # FM01729).

Certifications Supervisor
Jonathan Seewald

PC071106100 Page: 1 of 1 11/06/2007

Certificate Swagelok weld couplings 6 mm

14 Appendix D: Hydraulic Connector material certificates

Parker Aerospace-Stratoflex Division

MATERIAL CONTROL LABORATORY
2575 West 5th Street
Jacksonville, FL 32254
Phone: (904) 389-3400

DATE 9/26/2007
P.O. 361
RECEIVER 0006834
HEAT TREAT
IBM NUMBER 1506802036
TEST REPORT/CERTIFICATION

MCL# PB 7270
HEAT G12673K10
SIZE/PART# 9/16" DIA
SPECIFICATION AMS 5659L (15CR-5NI)RES386
MATERIAL CODE
QUANTITY 48 IN.

The test report/certification supplied with raw material have been reviewed by Parker/Stratoflex Quality Control and meet the requirements of the above referenced specifications.

Addtional Heat Numbers and Quantities

Receiver:	0006834	Qty: 48	Receiver:	Qty:	
Receiver:	0014749	Qty: 48	Receiver:	Qty:	
Receiver:		Qty:	Receiver:	Qty:	
Receiver:		Qty:			

TESTS PERFORMED ☑ Domestic Material

Hardness:

☐ STRATOFLEX ROCKWELL:

☐ SUPPLIER ROCKWELL:

Notes: WAS MCL PB 7255 THAN WAS HEAT TREATED PER RES 386.

PERIODIC CONTROL:

This material has undergone scheduled periodic control by an approved, independent laboratory IAW OP-08-05 and test results confirm compliance with the above referenced specification.

APPROVED FOR RELEASE ☑

I hereby certify that the above information is true.

EXHIBIT 3-FORM 33

MCL TECHNICIAN
Craig DeHaan

Braddock Metallurgical, Inc.-Jacksonville

Certification

Order No.: 65282
Date: 05/07/2009
Entry Date: 04/10/2009
Page: 1 of 1

To:
PARKER STRATOFLEX
2575 WEST 5TH STREET

JACKSONVILLE FL 32254

Purchase Order No.: 05381
Packing List No.:
Material: 15-5 PH

We certify that the listed Parts / Material were treated as follows:

Quantity	Part Number / Part Name / Part Description	Pounds
2	RES 386 REV C LOT 1506802036 9/16" RND. STOCK	5

Total Order Quantity: 2
Total Order Pounds: 5

AMS2759/3E RES 386 REV. C

Insp. Type	Scale	Minimum	Maximum	Number	Other
Customer Requirements:					
Hardness	HRC	34.	37.		
Tensile	KSI	145.			
Yield	KSI	125.			
Elong	Pct.	13.			
R. A.	Pct.	45.			
Results:					
Hardness	HRC	34.	37.		PASSED
Tensile	KSI	160.			PASSED
Yield	KSI	156.			PASSED
Elong	Pct.	18.			PASSED
R. A.	Pct.	66.			PASSED

Pieces were aged to condition H1075 in furnace# 15 at 1075 F (+/-10F) for 246 minutes. Per AMS 2759/3E , RES 386 REV. C and your purchase order.

ALL KSI VALUES HAVE BEEN CONVERTED TO HRC VALUES PER ASTM A 370.

Gordon L. Young
Quality Assurance
Braddock Metallurgical Co. Inc. of Jacksonville

14600 Duval Place West Jacksonville FL 32218 Phone: 904-741-4777 Fax: 904-741-4813

Ref PR3055

Braddock Metallurgical, Inc.-Jacksonville

Certification

Order No.: 54303
Date: 09/25/2007
Entry Date: 09/24/2007
Page: 1 of 1

To:
PARKER STRATOFLEX
2575 WEST 5TH STREET

JACKSONVILLE FL 32254

Purchase Order No.: 00361
Packing List No.:
Material: 15-5 PH

We certify that the listed Parts / Material were treated as follows:

Quantity	Part Number / Part Name / Part Description	Pounds
1	RES 386 REV C LOT 1506802036 9/16" X 48" ROUND STOCK	5

Total Order Quantity: 1
Total Order Pounds: 5

AMS2759/3D RES 386 REV. C

Insp. Type	Scale	Minimum	Maximum	Number	Other
Customer Requirements:					
Hardness	HRC	34.	37.		
Results:					
Hardness	HRC	34.5	34.5 ✓		PASSED

Pieces were aged to condition H-1075 Per RES 386 REV C / AMS2759/3D in furnace#10 at 1075 F for 245 minutes.

PB7269

Quality Assurance
Braddock Metallurgical Co. Inc. of Jacksonville

14600 Duval Place West Jacksonville FL 32218 Phone: 904-741-4777 Fax: 904-741-4813

Parker Aerospace-Stratoflex Division

MATERIAL CONTROL LABORATORY
2575 West 5th Street
Jacksonville, FL 32254
Phone: (904) 389-3400

DATE 9/13/2007
P.O. 3236
RECEIVER 0006637
HEAT TREAT
IBM NUMBER 1507602036
TEST REPORT/CERTIFICATION

MCL# PB 7255
HEAT G12673K10
SIZE/PART# 9/16"
SPECIFICATION AMS 5659L (15CR-5NI)
MATERIAL CODE
QUANTITY 144 IN.

The test report/certification supplied with raw material have been reviewed by Parker/Stratoflex Quality Control and meet the requirements of the above referenced specifications.

Addtional Heat Numbers and Quantities

Receiver:	Qty:	Receiver:	Qty:
Receiver:	Qty:	Receiver:	Qty:
Receiver:	Qty:	Receiver:	Qty:
Receiver:	Qty:		

TESTS PERFORMED ☑ Domestic Material

Hardness:

☐ STRATOFLEX ROCKWELL:

☐ SUPPLIER ROCKWELL:

Notes:

PERIODIC CONTROL:

This material has undergone scheduled periodic control by an approved, independent laboratory IAW OP-08-05 and test results confirm compliance with the above referenced specification.

APPROVED FOR RELEASE ☑

I hereby certify that the above information is true.

EXHIBIT 3-FORM 33

MCL TECHNICIAN
Ken Britt

04-03-'07 15:41 FROM-

04/03/2007 TUE 11:26 FAX 7163660478 DUNKIRK SPECIALTY STEEL

Dunkirk Specialty Steel, LLC
A Universal Stainless & Alloy Products Company
P.O. Box 319
830 Brigham Rd.
Dunkirk, NY 14048

ISO 9001:2000
Registered Quality System

Material Certification

PAGE NUMBER: 1 of 1
PRINTED: 3/23/07 09:44

MILL ORDER: 0016758
PART NUMBER: IAC 35141
P.O. NUMBER: 01-13165
P.O. DATE: 2/29/2006

SOLD TO: A. M. CASTLE & CO.
3400 N. WOLF ROAD
FRANKLIN PARK, IL 60131-1394

SHIP TO: A.M. CASTLE & CO.
3400 NORTH WOLF ROAD
FRANKLIN PARK, IL 60131

Material Description: STAINLESS STEEL ROUND BAR 15-5 BAR+ADD+VAR SOLUTION ANNEALED CENTERLESS GROUND ASTM A564-04 (type XM-12 solution treated), Castle ANC 3155-01 Rev. 19, AMS 2300K (condition A), UNS# S15500, AMS 5659L(Type 1),

Size: .5625 DIAM X 132.0000 MIN/ 156.0000 MAX RANDOM LENGTH

Heat Number	TOP	WT
G12673K1G		

C 0.046	MN 0.54	SI 0.34	B 0.002	P 0.022	
CR 14.42	W <0.05	V 0.09	NI 4.68	MO 0.27	
CO <0.05	CU 3.31	SN 0.007	PB	CB 0.32	
TA <0.01	AL <0.01	TI <0.01	FE	B 0.001	
O	MG	CA	SE	ZR	
AG	BI	N 0.020	BE	CO	

HARDNESS:	363 BHN					
H900 CAP:	UTS/ KSI 205.8	.2%Y/S KSI 203.3	%EL 19.0	%R/A 58.0	HARDNESS 404 BHN	

MAGNETIC PARTICLE: F/S = 0/0
FERRITE: <2%
MICRO TEST: ACCEPTABLE
MACRO ETCH TEST: ACCEPTABLE.
THIS MATERIAL WAS SOLUTION TREATED AT A MINIMUM TEMPERATURE OF 1900°F FOR AN APPROPRIATE TIME FOLLOWED BY AIR COOLING
COUNTRY OF ORIGIN: USA

CASTLE METALS CORP.
DATE RCVD 4/9/07
IAC 35141
APPROVED BY

/S/Harry Gawronski 03/23/07
/S/Harry Gawronski, Manager Q.A. Date

MELTED & MANUFACTURED IN COMPLIANCE WITH DFARS 252.225-7014 ALT 1. MELTED BY USAP IN BRIDGEVILLE, PA., USA
Certification IAW DIN 50 049 / EN 10204 3.1B. The Test Results Shown Are Certified To Be A Correct Statement Of Records That We
Derived From Testing Samples Of The Material. Results Meet Applicable Specifications. No Welding Was Performed On The Materia
Supplied On This Order. Material Is Free From Mercury Contamination. Material Is Of NAFTA Origin.

15 Appendix E: Intermediate CRES 347 material certificate

SALOMON'S METALEN B.V.
Gotenburgweg 24
9723 TL GRONINGEN
Tel. 050 - 542 12 00 Fax. 050 - 541 68 92
www.salomons-metalen.nl
info@salomons-metalen.nl

Dunkirk Specialty Steel, LLC

ISO 9001:2000
Registered Quality System

Material Certification

MILL ORDER: 0020963
PART NUMBER: S#41130
P.O. NUMBER: 44556-9
P.O. DATE: 3/8/2007 1
PAGE NUMBER: 1 of 1
PRINTED: 8/30/07 14:22

SOLD TO

SHIP TO

Material Description: STAINLESS STEEL ROUND BAR 347H EAF+AOD ANNEALED COLD DRAWN ASTM A484-05a, ASTM A276-05a (347 condition A, CF), ASME SA479-05 (347H except Grain size), ASTM A320-05a (B8C/Class 1), ASTM A193-05 (B8C/Class 1), ASTM A479-05a (347H condition A except Grain Size), AMS-QQ-S-763B (347 condition A, CF), Federal QQ-S-763F, AMS 5646M (CF).

Size: .2500 DIAM X 132.0000 MIN/ 156.0000 MAX RANDOM LENGTH

Heat Number													
G13230	FNL	W#	C	0.046	MN	1.66	SI	0.28	S	0.024	P	0.031
			CR	17.37	W	<0.05	V	0.07	NI	9.36	MO	0.40
			CO	0.13	CU	0.44	SN	0.009	PB		CB	0.69
			TA	<0.01	AL	<0.01	TI	<0.01	FE		B	
			O		MG		CA		SE		ZR	
			AG		BI		N	0.020	HG		CO	

TENSILE:	T/S KSI	Y/S KSI	%EL	%R/A
	107.8	86.7	33.5	68.5

HARDNESS: 228 BHN
GRAIN SIZE: 9.5
MICRO TEST: ACCEPTABLE
MACRO ETCH TEST: ACCEPTABLE
INTERGRANULAR CORROSION TEST: O.K. (ASTM-A262-02A PRACTICE E)
KNOWINGLY RECORDING FALSE, FICTITIOUS OR FRAUDULENT STATEMENTS
OR ENTRIES ON THIS DOCUMENT MAY BE PUNISHED AS A FELONY UNDER
FEDERAL STATUTES INCLUDING FEDERAL LAW, TITLE 18 CHAPTER 47.
3# 41130
MELT SOURCE: UNIVERSAL/DUNKIRK
MATERIAL MELTED IN THE USA BY UNIVERSAL STAINLESS & ALLOY PRODUCTS, BRIDGEVILLE, PA
MATERIAL MANUFACTURED IN THE USA

/S/Harry Gawronski

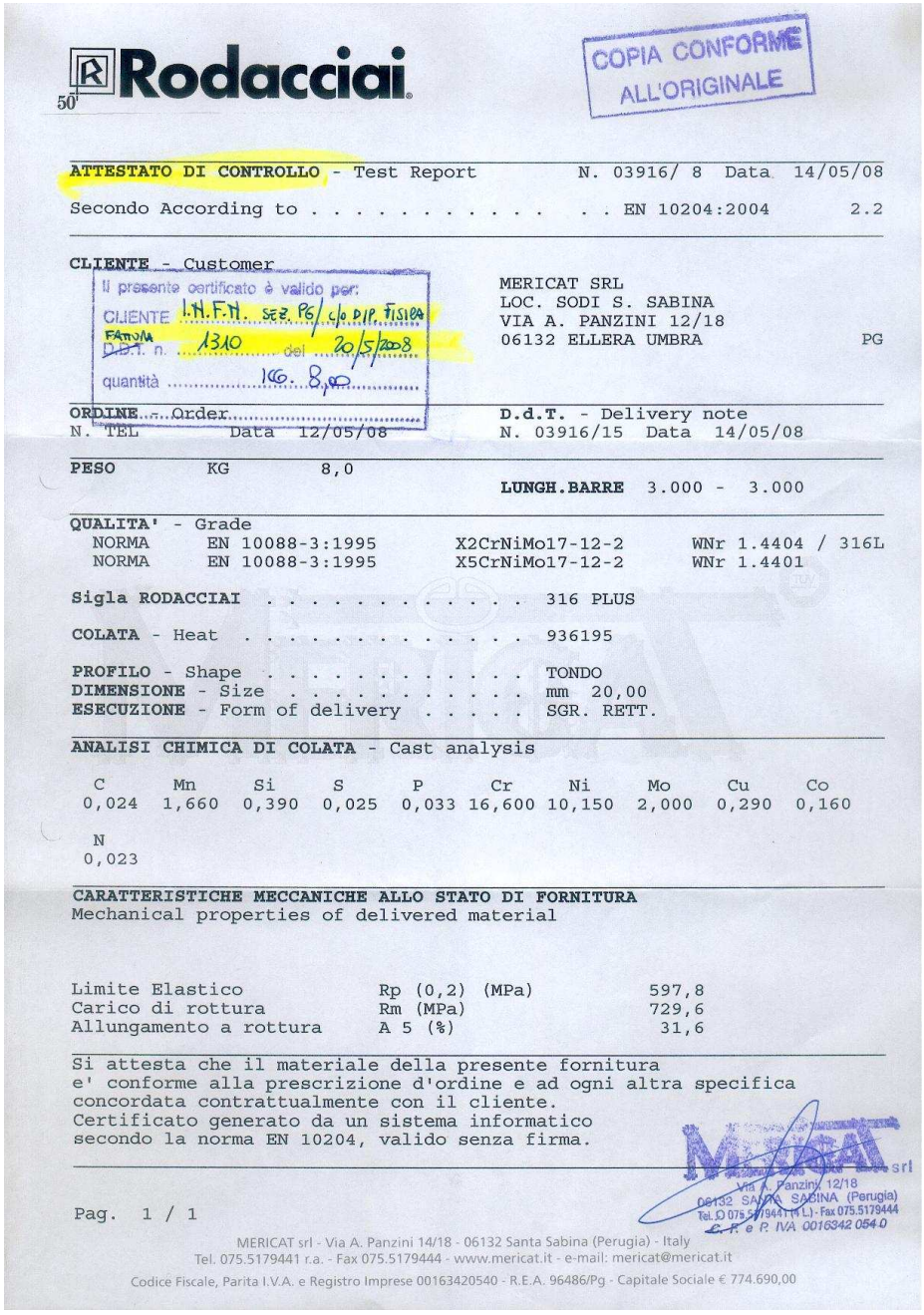
>H.J.Gawronski, Manager Q.A.

08/30/07
Date

Bu. 5/29/08

MELTED & MANUFACTURED IN COMPLIANCE WITH DFARS 252.225-7014 ALT 1. MELTED BY USAP IN BRIDGEVILLE, PA., USA
Certification IAW DIN 50 049 / EN 10204 3.1B. The Test Results Shown Are Certified To Be A Correct Statement Of Records That Were Derived From Testing Samples Of The Material. Results Meet Applicable Specifications. No Welding Was Performed On The Material Supplied On This Order. Material Is Free From Mercury Contamination. Material Is Of NAFTA Origin.

16 Appendix F: Condenser manifolds material certificate 316L



Rodacciai

COPIA CONFORME ALL'ORIGINALE

ATTESTATO DI CONTROLLO - Test Report N. 03916/ 8 Data 14/05/08

Secondo According to . . . . . EN 10204:2004 2.2

CLIENTE - Customer

Il presente certificato è valido per:
CLIENTE I.N.F.N. SEZ. PG/ c/o DIP. FISICA
FAttura
D.D.T. n. 1310 del 20/5/2008
quantità 166. 8,00

MERICAT SRL
LOC. SODI S. SABINA
VIA A. PANZINI 12/18
06132 ELLERA UMBRA PG

ORDINE - Order
N. TEL Data 12/05/08

D.d.T. - Delivery note
N. 03916/15 Data 14/05/08

PESO KG 8,0

LUNGH.BARRE 3.000 - 3.000

QUALITA' - Grade

NORMA	EN 10088-3:1995	X2CrNiMo17-12-2	WNr 1.4404 / 316L
NORMA	EN 10088-3:1995	X5CrNiMo17-12-2	WNr 1.4401

Sigla RODACCIAI . . . . . 316 PLUS

COLATA - Heat 936195

PROFILO - Shape . . . . . TONDO
DIMENSIONE - Size . . . . . mm 20,00
ESECUZIONE - Form of delivery . . . . . SGR. RETT.

ANALISI CHIMICA DI COLATA - Cast analysis

C	Mn	Si	S	P	Cr	Ni	Mo	Cu	Co	N
0,024	1,660	0,390	0,025	0,033	16,600	10,150	2,000	0,290	0,160	0,023

CARATTERISTICHE MECCANICHE ALLO STATO DI FORNITURA
Mechanical properties of delivered material

Limite Elastico	Rp (0,2) (MPa)	597,8
Carico di rottura	Rm (MPa)	729,6
Allungamento a rottura	A 5 (%)	31,6

Si attesta che il materiale della presente fornitura
e' conforme alla prescrizione d'ordine e ad ogni altra specifica
concordata contrattualmente con il cliente.
Certificato generato da un sistema informatico
secondo la norma EN 10204, valido senza firma.

MERICAT srl
Via A. Panzini 12/18
06132 SANTA SABINA (Perugia)
Tel. 075.5179441 (r.a.) - Fax 075.5179444
C.F. e P. IVA 00163420540

Pag. 1 / 1

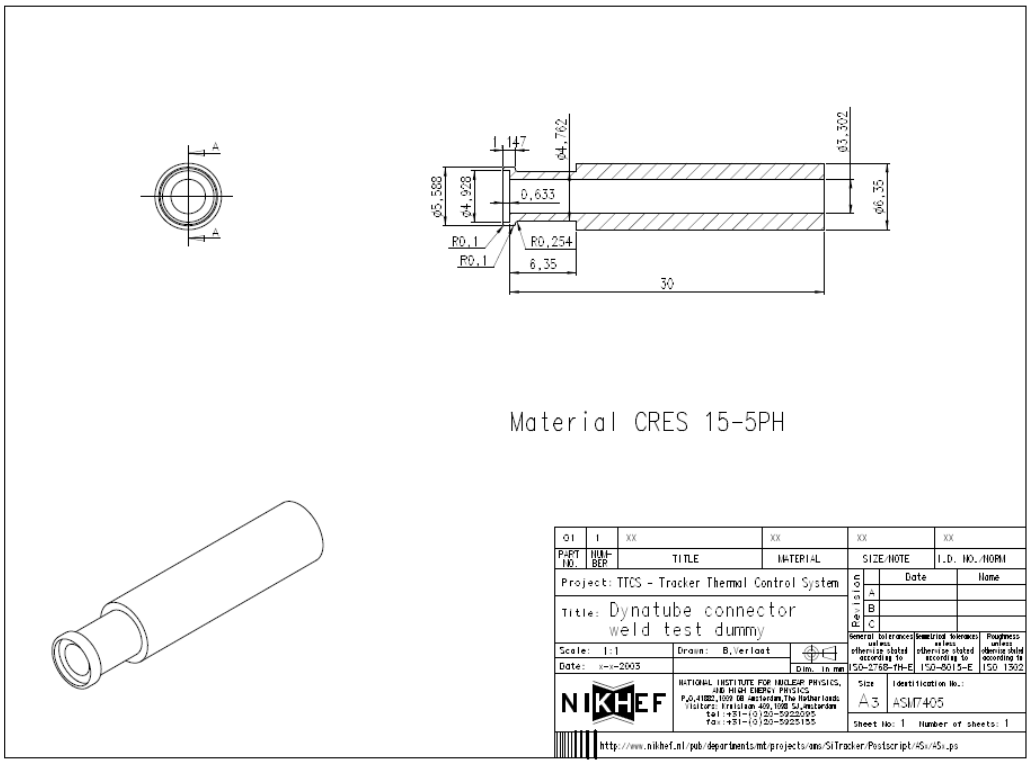
MERICAT srl - Via A. Panzini 14/18 - 06132 Santa Sabina (Perugia) - Italy
Tel. 075.5179441 r.a. - Fax 075.5179444 - www.mericat.it - e-mail: mericat@mericat.it
Codice Fiscale, Parita I.V.A. e Registro Imprese 00163420540 - R.E.A. 96486/Pg - Capitale Sociale € 774.690,00

17 Appendix G: Acceptance criteria for Class B pressure containing components

SURFACE INSPECTION ACCEPTANCE CRITERIA - CLASS B - Pressure Containing Components

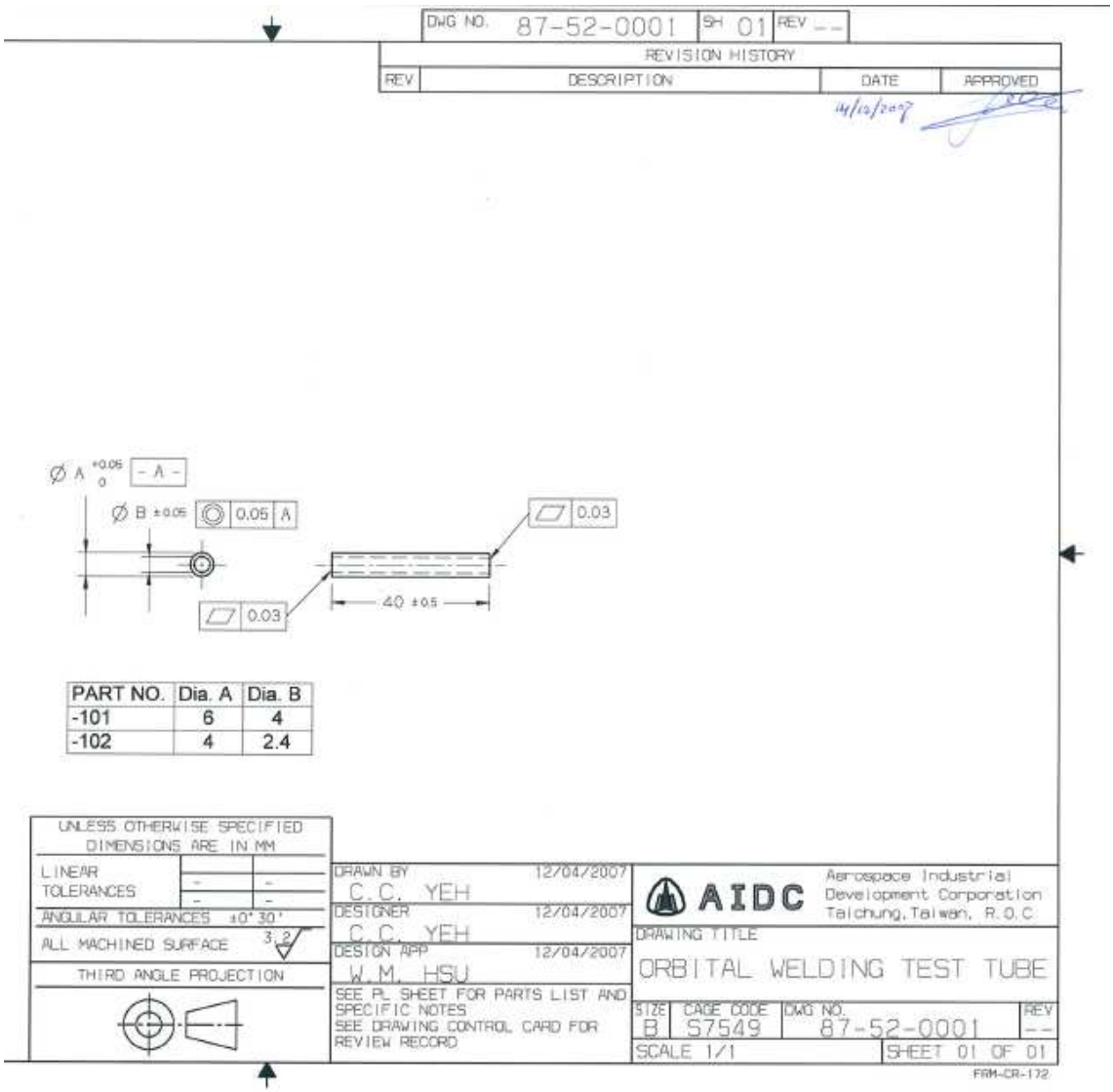
Size and Appearance of Groove Welds	Minimum size as specified on drawing. If profile requirements are not specified on the drawing, the weld shall be convex with a maximum reinforcement as stated herein. Any profile is unacceptable where the weld to base metal transition forms a sharp notch or reduces the base metal thickness (T) beyond the minimum specified on the drawing.
Size and Appearance of Fillet Welds	Minimum size as specified on drawing. If profile requirements are not specified on the drawing, the weld shall be flat or slightly convex with a maximum reinforcement as stated herein. Any profile is unacceptable where the weld to base metal transition forms a sharp notch or reduces (T) beyond the minimum specified on the drawing.
Cracks	None allowed.
Undercut	Undercut shall not exceed 15% of the total weld length. The depth of any undercut indication where T < 0.035", undercut shall not exceed 10% of T. Where T is >/= 0.035" and </= 0.09", undercut shall not exceed 15% of T or 0.010", whichever is the lesser. Where T > 0.09", the depth of undercut shall not exceed 0.015".
Pores or Voids	The maximum diameter shall not exceed 0.02" or 1/3 of T, whichever is the lesser. Indications less than .010" in diameter shall not be considered.
Weld Face or Root Concavity or WM Thinning	Concavity shall not exceed 15% of T or 0.015", whichever is the lesser.
Overlap	None allowed.
Misalignment	Misalignment shall not exceed 15% of T or 0.025", whichever is the lesser.
Peaking	Weld joint peaking shall not exceed a total of 5 degrees.
Weld Face or Root Convexity	Reinforcement, or melt-thru, shall not exceed 20% T or 0.06", whichever is the lesser.
Surface Discoloration	A black - brown color is not allowed.
Surface Roughness	Surface finish of welds and adjacent material resulting from processes used to remove weld reinforcement and otherwise shall not exceed 63 microinches.
General Workmanship	Weld deposits, face and root reinforcement and adjacent base metal shall display a smooth and uniform appearance. The weld toes shall blend smoothly into the base metal without unfused overlaps or undercut exceeding that specified.

18 Appendix H: Weld sample drawings connector dummies



For the weld qualification of the intermediate material the samples are exact copies of the flight parts as shown in Appendix A and B.

19 Appendix I: Weld sample drawing transport tubes



20 Appendix J: Burst test requirements TTCB weld sample tubes

For the structural verification a burst test need to be performed. The following is copied from the AMS structural verification requirements document:

B1: Where "MDP" stands for "Maximum Design Pressure". MDP for a pressurized system shall be the highest pressure defined by the maximum relief pressure, maximum regulator pressure **or maximum temperature**.
B2: The "Ultimate pressure factor" is a multiplying factor applied to the MDP to obtain ultimate pressure. Pressurized components are to be designed to the following factors of safety.

Table:

Lines and fittings:	Burst	Proof
Diameter <1.5"	***4.0***	***1.5***
Diameter =>1.5"	*2.5*	*1.5*
Other components	*2.5*	*1.5*

For the TTCB burst sample test it follows that the burst test need to be performed for 4 * MDP. The MDP for TTCS = 160 bar meaning the burst pressure will be 640 bar for the tubing.

The burst test can be performed with a Swagelok coupling (with stainless ferrule) closing on one side of the weld sample and a connecting coupling (with stainless ferrule) on the other side to apply the pressure.
Figures of the configurations are shown on the next page.
Pay attention to personal safety aspects and perform the test such that no connector can be bulleted around the area.
For the weld-coupling to weld coupling type of welds, weld additional tube to the connectors to be able to perform the burst test. Drawback is that 3 welds need to perfect but this is the most straight forward way to perform the test.

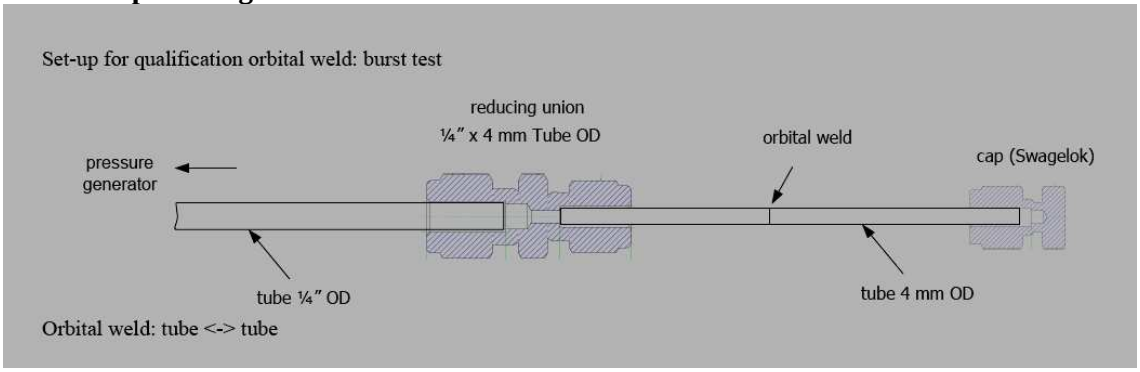
Acceptance criteria

1. He-leak tightness before burst $<1*10^{-9}$ mbarl/s (or $0{,}9708*10^{-9}$ atm cc /s)
2. The burst sample shall withstand the burst pressure

Documentation

1. Document pressures
2. The burst sample deformation shall be visually inspected and documented (photographed)

Burst sample configurations



Figuur 20-1: Type tube-tube weld

21 Appendix K: PQR

YOUR COMPANY/ORG name goes here

Page 1 of 2

ORBITAL TUBE GAS TUNGSTEN ARC WELDING PROCEDURE QUALIFICATION RECORD (PQR)

PQR Number _____ Revision _____ Company / Organization _____

Supporting WPS no.(s) _____ Welding Process(es) Automatic Orbital Tube Gas Tungsten Arc

BASE and FILLER METAL :

Material number _____ Group _____ to Material number _____ Group _____

Material spec., type, and grade _____ to Material spec., type, & grade _____

Base metal thickness range _____

Pipe / Tube diameter _____ Wall thickness _____

Filler metal F No. _____ AWS Class & Spec. _____

Consumable Insert, AWS Class & Spec. _____

GAS :

Torch gas(es) _____

% Composition _____ Flow Rate _____

Prepurge Time _____ Postpurge Time _____

Backing gas(es) _____

% Composition _____ Flow rate _____

Prepurge Time _____ Postpurge Time _____

WELDING SET-UP :

Power Supply (Model) _____

Weld Head(s) _____

Joint Position(s) _____

Tungsten type _____ Diameter _____ Arc gap _____

Tip diameter _____ Tip angle _____

Weld direction _____ Pulse Mode _____

PRE and POSTWELD HEAT :

Preheat temperature minimum _____

Preheat temperature maximum _____

Interpass temperature minimum _____

Interpass temperature maximum _____

Postweld HeatTreatment _____

WELD SETTINGS :

Start current (amps) _____ Upslope (sec.) _____

Level Slope Time (sec.) _____ Downslope (sec.) _____

Start Delay (sec.) _____ Override (%) _____

Finish Current (amp) _____ Fixture Speed (RPM) _____

Weld Timer (on/off) _____ Step Mode (on/off) _____

Wire Mode (on/off) _____ Finish Current _____

JOINT DESIGN :

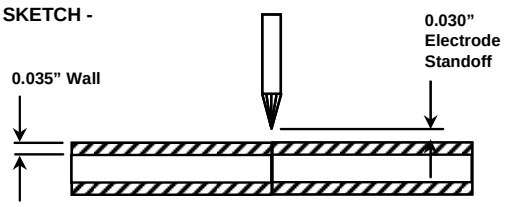
Joint type _____

Groove angle _____ Radius _____ Land _____

Root opening _____ Size of fillet _____

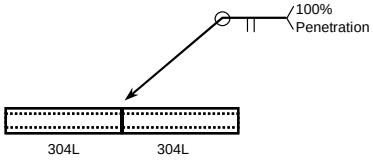
Socket weld pull-back _____

SKETCH -



NOMINAL HEAT INPUT CONDITIONS :

Level Number	Weld Time (sec.)	Allowable Current (amps) Settings HIGH +5%	HIGH Nominal	LOW -5%	LOW Nominal	Pulse Rate (pps)	Pulse Width Nominal



TECHNIQUE :

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of the NASA / JSC PRC-0010.

Qualifier : _____ Reviewed by : _____

Date : _____ Approved by : _____

PROCEDURE QUALIFICATION RECORD (PQR) for ORBITAL TUBE GAS TUNGSTEN ARC WELDING

PQR No. _____

TENSILE TEST SPECIMENS :

Type : _____ Tensile specimen size : _____ Area: _____

Groove ( ) Socket Lap w/fillet ( )

Tensile test results : (minimum required UTS : _____ psi)

Specimen No.	O.D., in.[(a)]	Wall Thkns, in.	Area, in^2	Max Load, lbs	F_{tu}, psi	Type Failure/Loc

GUIDED BEND TEST SPECIMENS - SPECIMEN SIZE: _____

Type	Result	Type	Result

MACRO - EXAMINATION RESULTS : _____

IMPACT TEST SPECIMENS

Type : _____ Size : _____

Test temperature : _____

Specimen location : WM = weld metal; BM = base metal; HAZ = heat - affected zone

Test results :

Welding position	Specimen location	Energy absorbed (ft. - lbs.)	Ductile fracture area (percent)	Lateral expansion (mils)

IF APPLICABLE **RESULTS**

Hardness tests : ( ) Values _____	Acceptable ( )	Unacceptable ( )
Visual Inspection ( ) _____	Acceptable ( )	Unacceptable ( )
Torque ( ) psi _____	Acceptable ( )	Unacceptable ( )
Proof test ( ) Method _____	Acceptable ( )	Unacceptable ( )
Chemical analysis ( ) _____	Acceptable ( )	Unacceptable ( )
Non-destructive exam ( ) Process _____	Acceptable ( )	Unacceptable ( )
Other _____	Acceptable ( )	Unacceptable ( )

Mechanical testing conducted by (Company) _____ Lab No. _____

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of the NASA / JSC PRC-0010.

Qualifier : _____ Reviewed by : _____

Date : _____ Approved by : _____

22 Appendix L: WPS

YOUR COMPANY/ORGANIZATION NAME goes here

ORBITAL TUBE ARC WELDING PROCEDURE SPECIFICATION (WPS)

WPS Number _____ Revision _____ Company / Organization _____

Supporting PQR no.(s) _____ Welding Process(es) Automatic Orbital Tube Gas Tungsten Arc

BASE and FILLER METAL :

Material number _____ Group _____ to Material number _____ Group _____

Material spec., type, and grade _____ to Material spec., type, & grade _____

Base metal thickness range _____

Pipe / Tube diameter _____ Wall thickness _____

Filler metal F No. _____ AWS Class & Spec. _____

Consumable Insert, AWS Class & Spec _____

GAS :

Torch/Head gas(es) _____

% Composition _____ Flow Rate _____

Prepurge Time _____ Postpurge Time _____

Backing gas(es) _____

% Composition _____ Flow rate _____

Prepurge Time _____ Postpurge Time _____

WELDING SET-UP :

Power Supply (Model) _____

Weld Head(s) _____

Joint Position(s) _____

Tungsten type _____ Diameter _____ Arc gap _____

Tip diameter _____ Tip angle _____

Weld direction _____ Pulse Mode _____

PRE and POSTWELD HEAT :

Preheat temperature minimum _____

Preheat temperatue maximum _____

Interpass temperature minimum _____

Interpass temperature maximum _____

Postweld HeatTreatment _____

WELD SETTINGS :

Start current (amps) _____ Upslope (sec.) _____

Level Slope Time (sec.) _____ Downslope (sec.) _____

Start Delay (sec.) _____ Override (%) _____

Finish Current (amp) _____ Fixture Speed (RPM) _____

Weld Timer (on/off) _____ Step Mode (on/off) _____

Wire Mode (on/off) _____

JOINT DESIGN :

Joint type _____

Groove angle _____ Radius _____ Land _____

Root opening _____ Size of fillet _____

Socket weld pull-back _____

NOMINAL HEAT INPUT CONDITIONS :

Level Number	Weld Time (sec.)	Allowable Current (amps) Settings HIGH +5%	HIGH Nominal	HIGH -5%	LOW Nominal	Pulse Rate (pps)	Pulse Width Nominal
1							
2							
3							
4							

SETUP SKETCH -

TECHNIQUE :

Joint cleaning _____

Other _____

We certify that this welding procedure and schedule were qualified in accordance with the requirements of NASA / JSC PRC-0010.

Prepared By _____ Org. _____ Date _____

Approved By _____ Org. _____ Date _____

23 Appendix M: Swagelok Micro-weld head series 4

www.swagelok.com

Orbital Welding System
Micro Weld Heads

Series 4 and Series 8

- Available for tube outside diameters ranging from 1/16 to 1/2 in. and 2 to 12 mm
- Features a compact size for easy access to confined welding areas
- Weld head includes arc gap gauge, centering gauge, micro fixture tool, tool package, and tungsten electrodes

Swagelok

2 Orbital Welding System—Series 4 and Series 8

Features

- Miniature design permits access to confined welding areas
- Optical speed control—no tachometer or calibration required
- Improved productivity from the ability to set up one fixture while welding with another fixture

Series 4

- For weld joint outside diameters of 1/16 to 1/4 in. and 2 to 6 mm
- Rigid- or flexible-drive weld head for ultimate versatility

Series 8

- For weld joint outside diameters of 1/8 to 1/2 in. and 3 to 12 mm

Technical Data

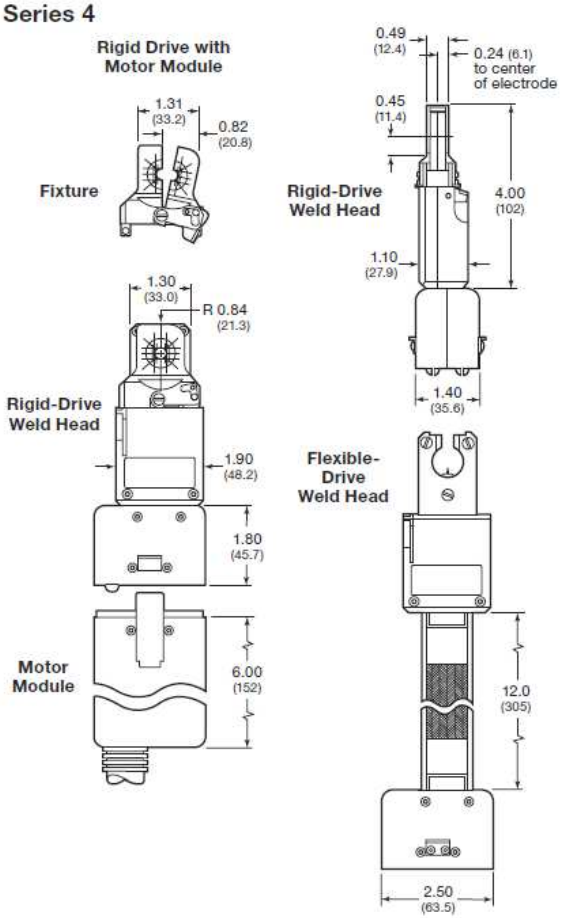
Weld Joint Nominal Outside Diameter	Weld Head Series	Minimum Axial Clearance in. (mm)	Minimum Radial Clearance in. (mm)	Maximum Average Weld Current	Maximum Welds per Hour
1/16 to 1/4 in.; 2 to 6 mm	4	0.490 (12.4)	0.84 (21.3)	30 A	10 to 12①
1/8 to 1/2 in.; 3 to 12 mm	8		1.00 (25.4)	38 A	12②

① Based on welding 1/4 × 0.035 in. 316L tubing.
② Based on welding 1/2 × 0.049 in. 316L tubing.

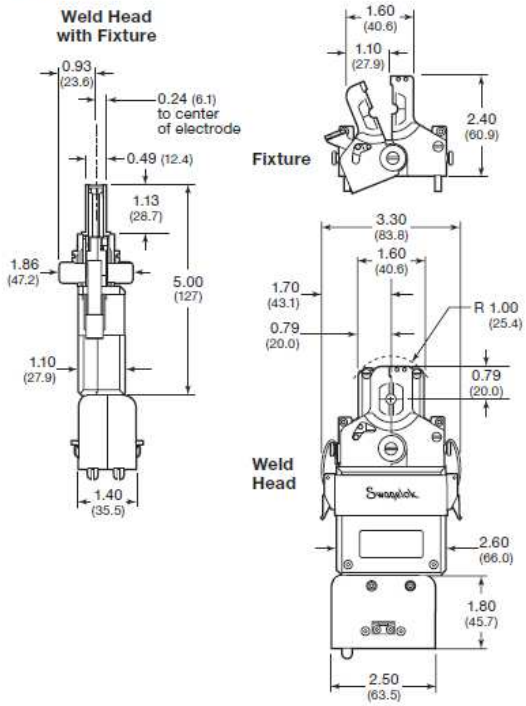
Dimensions

Dimensions, in inches (millimeters), are for reference only and are subject to change.

Series 4



Series 8



Swagelok

Ordering Information

Swagelok® Series 4 and Series 8 micro weld heads are shipped with an arc gap gauge, centering gauge, tool package, fixture tool, assorted electrode packages, and user's manual.

Series 4 Flexible-Drive Weld Head

Series 4 Rigid-Drive Weld Head

Series 8 Weld Head

Micro Weld Heads

Series	Weld Head Drive	Ordering Number
4	Rigid	SWS-4MRH-B
	Flexible	SWS-4MFH-B
8	Rigid	SWS-8MRH-B

Motor Modules

- Only one motor module is necessary to operate either series weld head model.
- Has polarized power connectors to ensure proper weld head/power supply connections

Motor Module

Description	Ordering Number
Motor module	SWS-M-MTR-B

Micro Weld Head Fixtures

- Front-load scissor action provides access to confined areas for close-coupled welding
- Cantilever design fixture collets compensate for tube outside diameter variations of ± 0.005 in. (0.13 mm)
- Laser-inscription on the fixtures assists user with parts orientation
- Split-base design provides component alignment adjustment

Series 4 Fixture

Series 8 Fixture

Weld Joint Nominal Outside Diameter in.	Ordering Number
Series 4 Weld Head	
1/16	SWS-4MFB-01
1/8	SWS-4MFB-02
3/16	SWS-4MFB-03
1/4	SWS-4MFB-04
Series 8 Weld Head	
1/8	SWS-8MFA-02
1/4	SWS-8MFA-04
3/8	SWS-8MFA-06
1/2	SWS-8MFA-08

Weld Joint Nominal Outside Diameter mm	Ordering Number
Series 4 Weld Head	
2	SWS-4MFB-2MM
3	SWS-4MFB-3MM
4	SWS-4MFB-4MM
6	SWS-4MFB-6MM
Series 8 Weld Head	
5	SWS-8MFA-5MM
6	SWS-8MFA-6MM
8	SWS-8MFA-8MM
9	SWS-8MFA-9MM
10	SWS-8MFA-10MM
11	SWS-8MFA-11MM
12	SWS-8MFA-12MM

Accessories

Arc Gap Gauges

Swagelok arc gap gauges position the electrode precisely in the rotor for repeatable welds. The easy-to-use gauge helps eliminate errors associated with sight and feeler gauge adjustments. One arc gap gauge comes with the weld head.

Series	Ordering Number
4	CWS-4MAG
8	CWS-8MAG

Centering Gauges

The micro weld head centering gauge ensures accurate centering of weld components in the micro fixture. One centering gauge comes with the weld head.

Series	Ordering Number
4	CWS-4MCG
8	CWS-8MCG

Micro Fixture Tool

This tool engages the fixture latch for easy opening and closing of the micro weld head fixture. One micro fixture tool comes with the weld head.

Description	Ordering Number
Micro fixture tool	CWS-MFP-FIXTL

Cooling Plates

Swagelok cooling plates quickly absorb heat away from the micro weld head fixture and components after welding.

Series	Ordering Number
4	CWS-4MCP
8	CWS-8MCP

Bench Mounting Brackets

Swagelok bench mounting brackets attach rigid- or flexible-micro weld heads to a work bench. The Series 4 bracket features a quick-release mechanism for convenient operation.

Series	Ordering Number
4	CWS-4MBB
8	CWS-8MBB

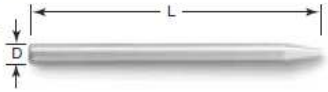
Weld Head Extension Cables

Swagelok weld head extension cables, in combination with the standard motor module, provide weld head operation of up to 50 ft (15.2 m) away from the power supply. Cables are available in lengths of 12.5 and 37.5 ft (3.8 and 11.4 m).

Extension Cable, ft (m)	Ordering Number
12.5 (3.8)	SWS-WHEC-B-12.5FT
37.5 (11.4)	SWS-WHEC-B-37.5FT

Tungsten Electrodes

Swagelok electrodes, available in packages of ten, provide consistent, repeatable welds. Electrodes consist of 2 % ceriated tungsten, axially ground to rigid specifications.



Weld Joint Nominal Outside Diameter		Electrode Diameter (D)	Electrode Length (L)	Ordering Number
in.	mm	in. (mm)	in. (mm)	
Series 4 Weld Head				
1/16, 1/8, 3/16	2, 3, 4	0.040 (1.0)	0.405 (10.3)	CWS-C.040-.405-P
1/4	6		0.325 (8.26)	CWS-C.040-.325-P
Series 8 Weld Head				
1/8	3, 5	0.040 (1.0)	0.450 (11.4)	CWS-C.040-.450-P
1/4	6, 8, 9		0.405 (10.3)	CWS-C.040-.405-P
3/8	10, 11		0.325 (8.26)	CWS-C.040-.325-P
1/2	12		0.281 (7.14)	CWS-C.040-.281-P

Safe Product Selection
When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange parts with those of other manufacturers.

Warranty Information

Swagelok products are backed by The Swagelok Limited Lifetime Warranty. For a copy, visit swagelok.com or contact your authorized Swagelok representative.

END OF DOCUMENT